Alexander Shifrin
Editor

Atlas of Adrenal Surgery

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In memory of my father, Leonid Shifrin, medical engineer and the inventor of thromboelastographs, and my uncle, pediatric surgeon, Vadim Shifrin, MD.

To my mother, Margarita Shifrina, for her love and endless support.

To my beloved children, Michael, Daniel, Benjamin, Julia, Christian, and Liam, who continue to provide perspective on what is truly important in life.

To the love of my life, Svetlana L. Krasnova, for her love, patience, and encouragement.

Preface

Minimally invasive surgery has become the standard-of-care approach for the treatment of adrenal tumors. As with cholecystectomies, current surgical approach for most adrenalectomies is performed either by anterior-lateral laparoscopic or by posterior retroperitoneoscopic approaches.

The *Atlas of Adrenal Surgery* is designed to illustrate different techniques on how to perform successful adrenalectomies by using different approaches. Knowledge of anatomy and precise surgical technique remain the foundation of high-quality surgery. The *Atlas* is written by renowned endocrine surgeons, experts in the field who are members of the American Association of Endocrine Surgeons and are not only involved in teaching and publishing but also have mastered this surgical technique and modernized it to the point of perfection!

This *Atlas* includes techniques of adrenalectomy by using laparoscopic transperitoneal, posterior retroperitoneal, and robotic approaches. Each procedure includes right and left adrenalectomy. Each chapter is started with a case description that defines the main aspect of surgery. Each picture, which is taken intraoperatively, is accompanied by corresponding drawings for easier understanding of the anatomical structures and steps of the procedure. In addition, each author provided a video of the same case as it is depicted in the chapter, which is annotated and can be accessed online via SpringerLink (link.springer.com). The *Atlas* also gives some common pitfalls of the procedure in order to avoid complications and improve patient outcomes.

We hope this *Atlas* will provide an indispensable source of knowledge to all surgeons, those who just started their career and those who are in the more advanced stages of their practice and are learning new techniques of adrenalectomy.

Neptune, NJ, USA — Alexander Shifrin, MD, FACS, FACE, ECNU, FEBS

Acknowledgments

The creation of this *Atlas*, covering the entire scope of adrenal surgery, was dependent on a team effort, which was possible only with the support and enthusiasm of the many individuals who contributed to this book, my colleagues who trusted me and dedicated their time and effort to make it happen. Special thanks to William Inabnet, Nancy Perrier, Quan-Yang Duh, and Laurent Brunaud, without whom this *Atlas* would have never come to life!

I am very thankful to my teachers, who dedicated their lives and efforts to the science of surgery. Those who made me into a surgeon and inspired me to produce this *Atlas*: Ali Bairov, MD; Steven Raper, MD; William Inabnet, MD; John Chabot, MD; Jerome Vernick, MD; and Martin Walz, MD.

Special thanks to the artists who worked on this *Atlas* at Springer; to my friend, endocrinologist and artist, Cheryl Rosenfeld, MD, who helped me start the project; to Executive Editor Richard Hruska, who believed in me; and to Senior Editor Lee Klein of Springer for his hard work and dedication.

Finally, I would like to thank the entire staff at Springer, who were very supportive from the first idea of this *Atlas* and maintained their enthusiasm until the end.

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Transabdominal Laparoscopic Left Adrenalectomy

1

Frederick Thurston Drake and Quan-Yang Duh

The patient with a left adrenal mass (Figs. 1.1 and 1.2) is intubated and then placed into the right lateral decubitus position with all pressure points padded. Both arms are partially extended into a comfortable "hugging" configuration with the right arm placed on a padded arm board and the left arm positioned on pillows or an elevated arm board. An axillary roll is placed just caudal to the right axilla to prevent brachial plexus palsy. We generally position the patient so he or she is reclining slightly more supine than in full decubitus position. The left flank is exposed, and the right lower ribs should be placed overlying the "break" in the operating table; this ensures that, when the table is flexed, the space between costal margin and iliac crest widens, allowing more working room for the laparoscopic instruments. Conceptually, the patient is positioned so that the upper pole of the kidney is placed on top of the break in the bed.

We obtain access to the abdomen via the Veress needle technique in the midclavicular line (Palmer's Point) and then place three additional ports, at equal intervals, with the last one in the anterior axillary line (Fig. 1.3 and Video 1.1). Our technique utilizes four 11-mm radially dilating ports. The camera is placed through Port #2, and the assistant's instrument (for retracting) is placed through Port #1. The primary surgeon operates through Ports #3 and #4.

The location of the splenic flexure can be quite variable, but the operation always begins by taking down the splenic flexure to expose the retroperitoneal structures posterior to it (Fig. 1.4): specifically, Gerota's Fascia, the distal pancreas,

Fig. 1.1 Computed tomography (axial) image of left adrenal mass

Fig. 1.2 Computed tomography (coronal) image of left adrenal mass

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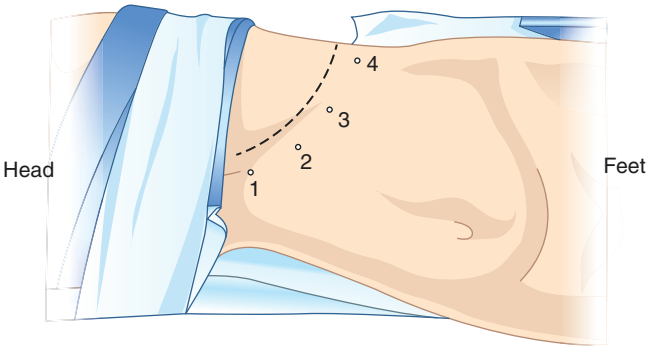

Fig. 1.3 Patient positioning for left transperitoneal laparoscopic adrenalectomy. Head is to the left of the image, and the tape is passing over the patient's chest. The numbers written caudal to the costal margin (*dotted line*) represent the four port sites

and the posterior aspect of the spleen. This may involve incising the superior aspect of the White Line of Toldt on the descending colon and carrying this around from distal to proximal on the colon, which releases the lateral and then the superior aspect of the splenic flexure. With this done, the retroperitoneum is exposed (Fig. 1.5).

One pitfall of left adrenalectomy may be encountered at this point: the misidentification of the correct plane of dissection. This can be particularly difficult in the case of an obese man with a large amount of intra-abdominal fat. It is crucial to develop the plane between the spleen/pancreas (in front) and the kidney/adrenal (in back) (Fig. 1.6). It is possible to misjudge in both directions: that is, to end up posterior to the kidney or to develop a plane between pancreas and spleen. Once the correct plane is identified, the investing connective tissues are divided layer by layer, which is generally done with the hook cautery; much of this dissection con-

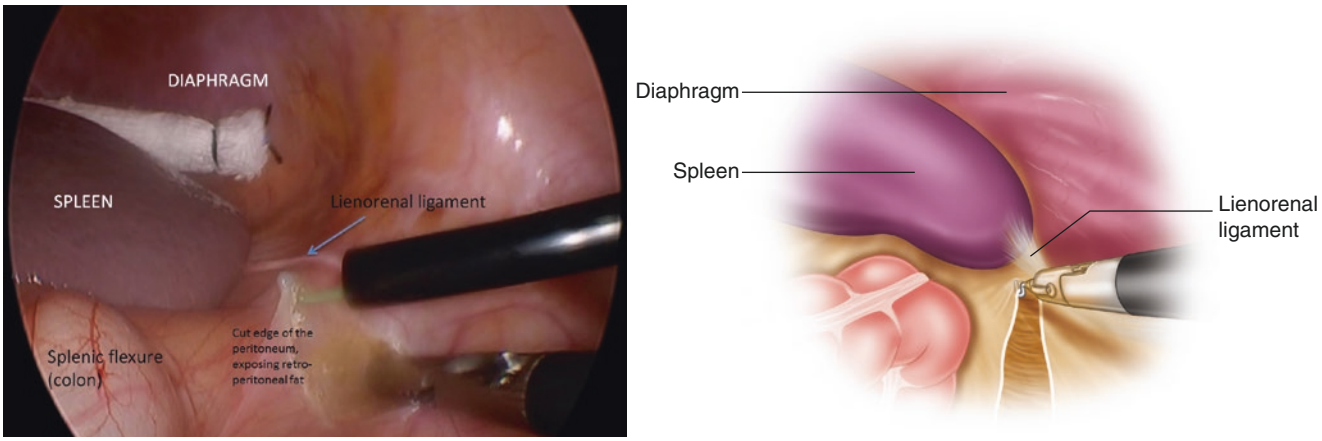

Fig. 1.4 Intraoperative image: opening the peritoneum to mobilize the splenic flexure and reveal the retroperitoneal fat

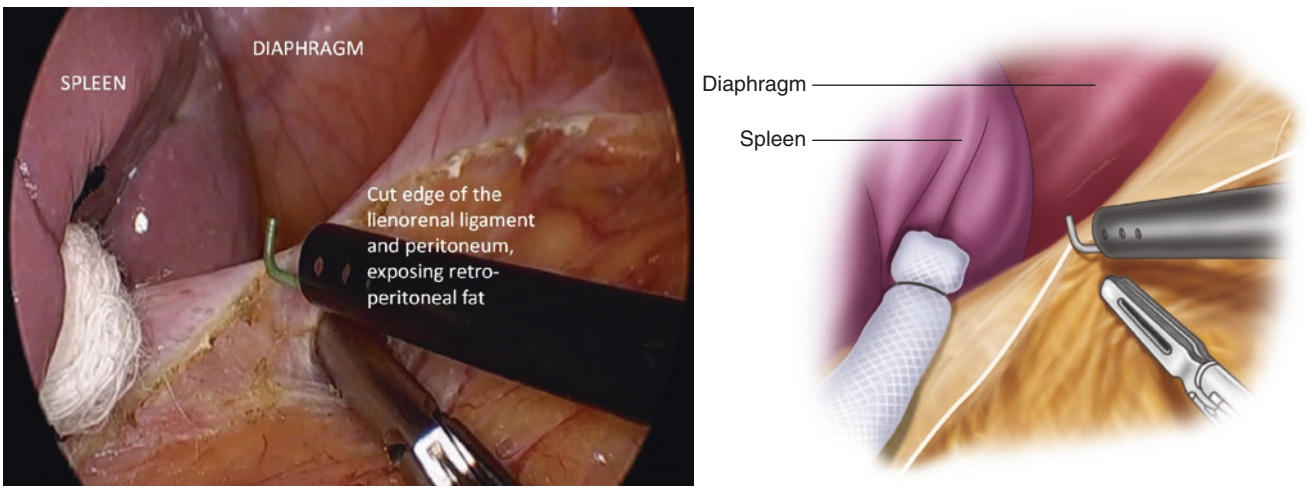

Fig. 1.5 Intraoperative image: exposing the retroperitoneum and gentle medial traction on the spleen

sists of dividing relatively avascular areolar planes. As the spleen and pancreas rotate medially, the posterior diaphragm and fundus of the stomach come into view.

Generally, the inferior phrenic vein will be identified at this point running along the medial border of the adrenal gland and the adrenal tumor. If possible, we follow the inferior phrenic vein down toward its junction with the adrenal vein and use this as a landmark to identify the adrenal vein (Figs. 1.7 and 1.8). Depending on the anatomy and our ability to retract the adrenal gland and tumor in a superior direction (and thus out of the renal fossa), we may dissect out the lateral border of the adrenal gland as well. This can improve mobility and retraction, and it also reduces back-bleeding from the gland once the adrenal vein has been ligated.

Ultimately, the adrenal vein is dissected free from the surrounding tissues, clipped, and divided. We always clip the renal vein side, then clip the adrenal gland side, and then place a third clip in the middle. The vein is divided leaving two clips on the renal vein side (Fig. 1.9). In general, division of the adrenal vein substantially improves mobility and allows the gland to be further retracted out of the renal hilum. A second important pitfall can be avoided here by remaining cautious in the dissection even after the vein is clipped. Dissection of the inferior aspect of the adrenal gland exposes a superior pole renal artery to risk of injury, which can cause renovascular hypertension. Some patients may also have accessory adrenal veins that are at risk for bleeding unless they are carefully controlled and divided. Once the gland can be safely elevated out of the hilum, dissection can proceed somewhat more liberally, and we generally use a bipolar vessel sealer (LigaSure) to take these bands of tissue and smaller vessels (Fig. 1.10).

Once the gland is free, it is placed into a 4 × 6-inch impermeable nylon bag, and the mouth of the bag is brought out through the most lateral port. The gland and tumor are then fragmented intracorporally—*within* the bag—while the bag remains under direct laparoscopic visualization to ensure that no intra-abdominal structures are injured during this

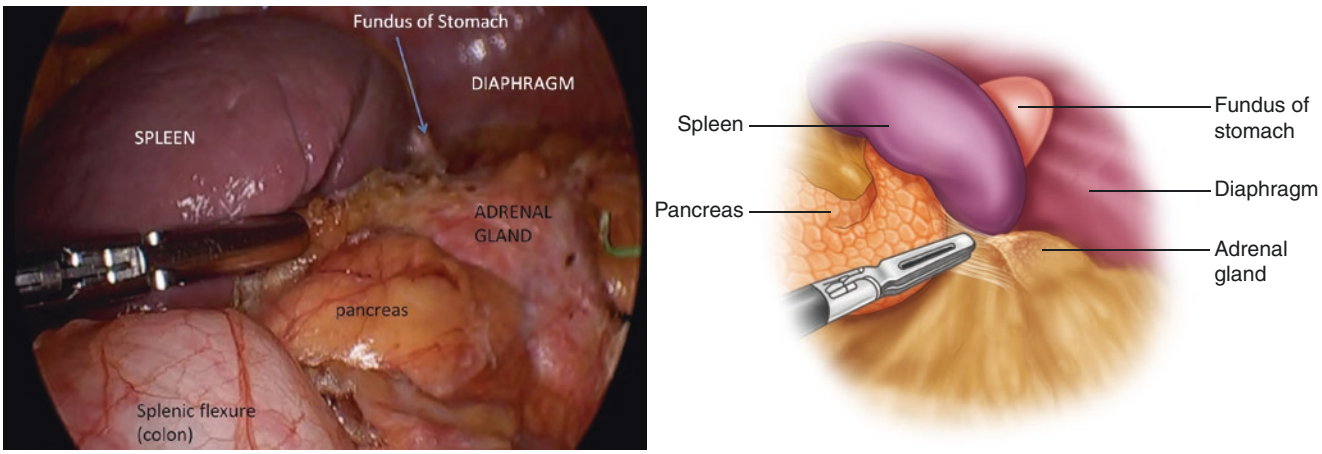

Fig. 1.6 Intraoperative image: anatomic relationships between the spleen, pancreas, diaphragm, and left adrenal gland

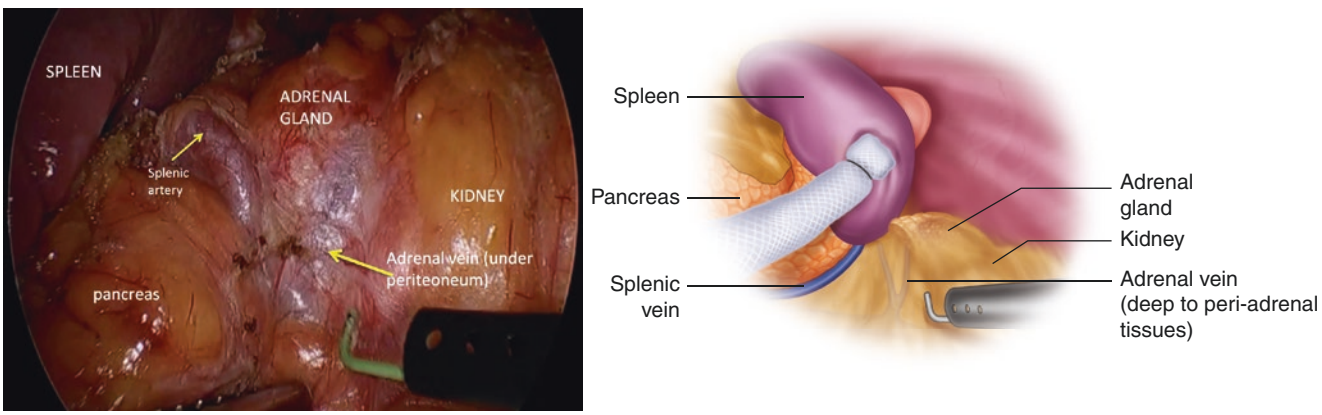

Fig. 1.7 Intraoperative image: anatomic relationships between the spleen, pancreas, kidney, adrenal vein, and left adrenal gland

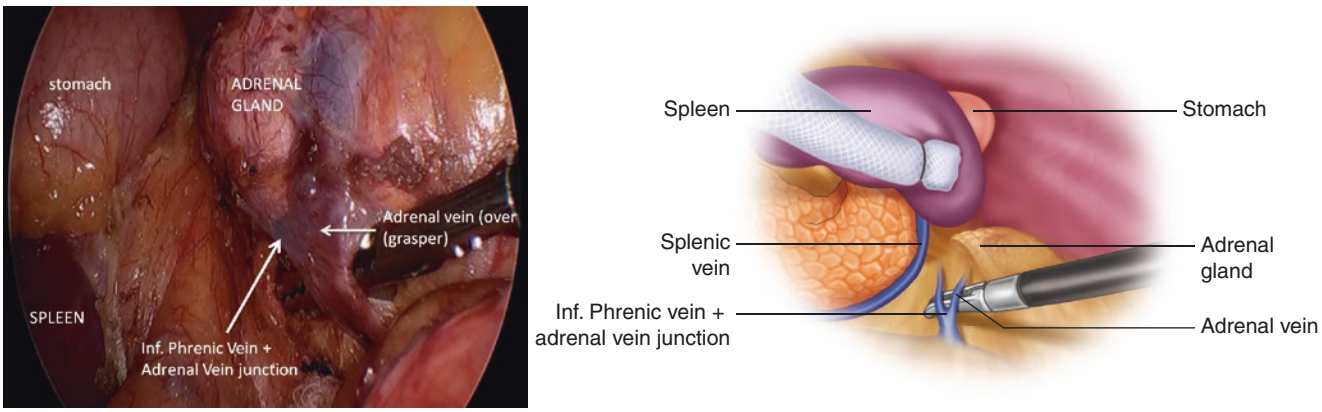

Fig. 1.8 Intraoperative image: dissection of the left adrenal vein

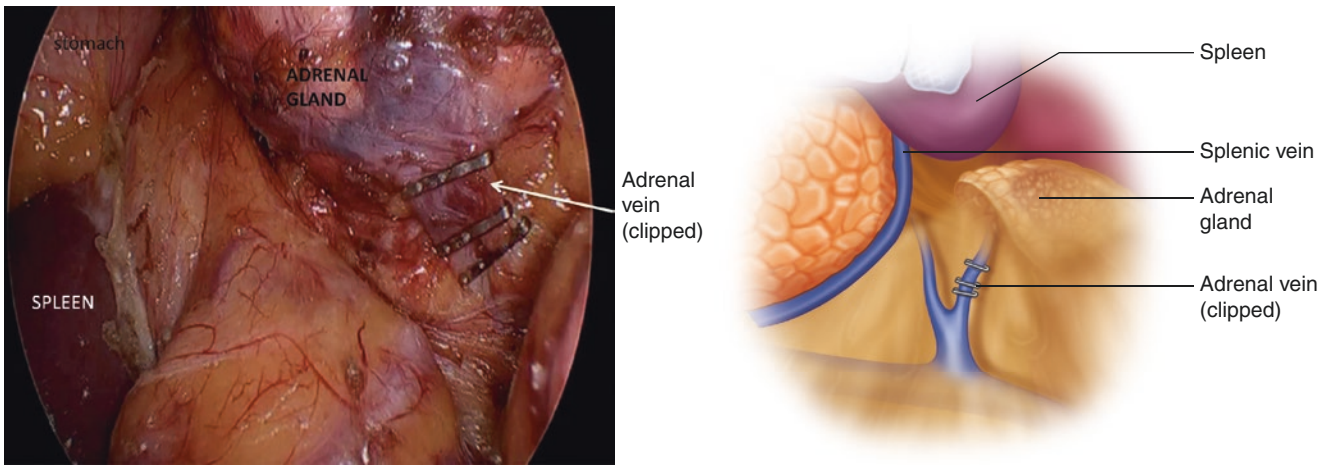

Fig. 1.9 Intraoperative image: clips placed on the left adrenal vein

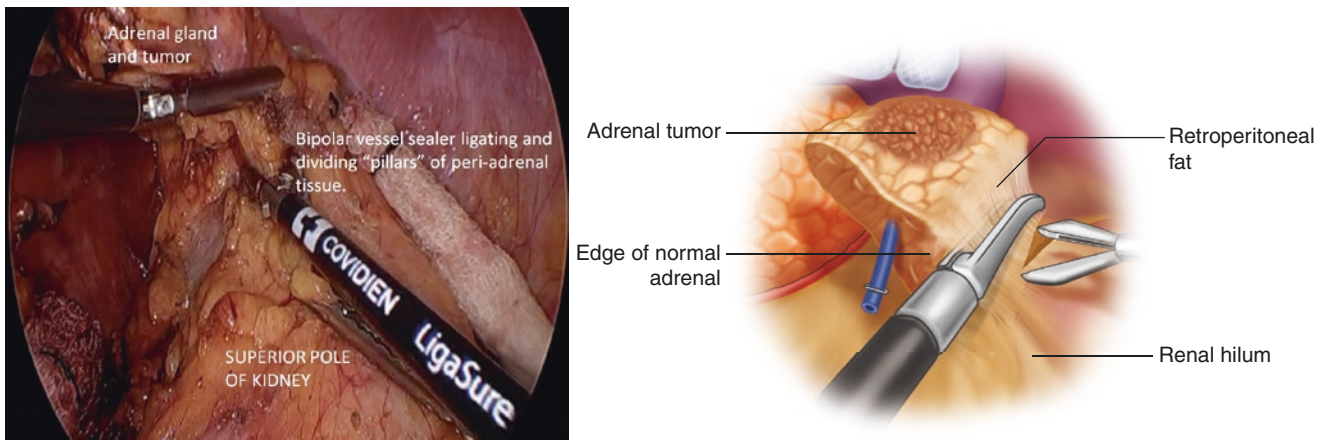

Fig. 1.10 Intraoperative image: dissection of the adrenal gland away from the superior pole of the left kidney. Note how the grasper is cradling and elevating the periadrenal gland tissues, not squeezing the gland itself

process. Once the gland has been removed piecemeal, a final inspection of the adrenal fossa is performed and hemostasis ensured. Pneumoperitoneum is released, trocars are removed, and the skin is closed.

Suggested Reading

Fassnacht M, Arlt W, Bancos I, Dralle H, Newell-Price J, Sahdev A, et al. Management of adrenal incidentalomas: European Society of Endocrinology Clinical Practice Guideline in collaboration with the European Network for the Study of Adrenal Tumors. Eur J Endocrinol. 2016;175(2):G1–G34.

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Laparoscopic Right Adrenalectomy (Transperitoneal Approach)

2

Toni Beninato and Quan-Yang Duh

Patient Presentation

A 44-year-old man was referred for evaluation of primary aldosteronism. He had hypertension for the previous 8 years and was on three antihypertensive medications. Evaluation after a pre-syncopal episode also revealed a potassium level of 2.5 mmol/L, for which he was taking potassium supplementation for the past year. He was otherwise healthy and in good physical condition. A CT scan showed a 1.0 × 1.2 × 0.8-cm right adrenal nodule with characteristics suggestive of an adenoma (Fig. 2.1). He had an aldosterone-to-renin ratio of 163. Adrenal vein sampling confirmed the presence of a right-sided aldosterone-producing lesion, and plans were made for laparoscopic right adrenalectomy.

Fig. 2.1 Axial view of CT scan of the abdomen demonstrating a right adrenal nodule

Procedure Description

The patient is taken to the operating room and general anesthesia is induced. A urinary catheter and orogastric tube are placed. No preoperative antibiotics or stress dose steroids are indicated in healthy patients undergoing adrenalectomy unless they have Cushing's syndrome. The patient is placed in the right lateral decubitus position with appropriate padding, and the table is flexed. The right flank is exposed and then prepped and draped in the usual sterile fashion. The placement of the four subcostal trocars is illustrated in Fig. 2.2. An incision is made at the #2 trocar site, and a

Fig. 2.2 Patient positioning for laparoscopic right adrenalectomy. The dots demarcate the costal margin, and the four incision sites are marked and numbered

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Veress needle is used to achieve pneumoperitoneum to a pressure of 15 mm Hg. When gaining access to the peritoneal cavity, end-tidal CO_2 and insufflation pressure should be monitored closely to ensure that the liver has not been punctured and insufflated, risking CO_2 embolism. When appropriate insufflation has been ensured, an 11-mm dilating trocar is placed. The other three ports are placed in sequence under direct visualization, #4, then #1, and finally #3, with equal distance between each port. Local anesthetic is injected into the skin, subcutaneous tissues, and peritoneum prior to making each incision. In general, port #1 is used for the fan liver retractor, port #2 for the camera, and ports #3 and #4 are the operating ports. This configuration can be adjusted throughout the case as necessary.

The liver is retracted medially, and the operating surgeon, with a grasper and L hook, takes down the right triangular ligament (Fig. 2.3). The dissection is continued superiorly, and the lateral attachments of the liver to the diaphragm are divided (Fig. 2.4). Once the liver is adequately mobile, it is retracted medially and superiorly to "open the book" and expose the retroperitoneum and the adrenal gland (Fig. 2.5). The concept of the "open book" technique involves retracting the "front pages of the book" (the liver) medially and the "back pages of the book" (the kidney and adrenal gland) laterally. The goal is to find the "spine" of the book and dissect along it toward the renal hilum until the right adrenal vein is encountered. Before encountering the right adrenal vein, the superior adrenal artery is dissected (Fig. 2.6) and divided

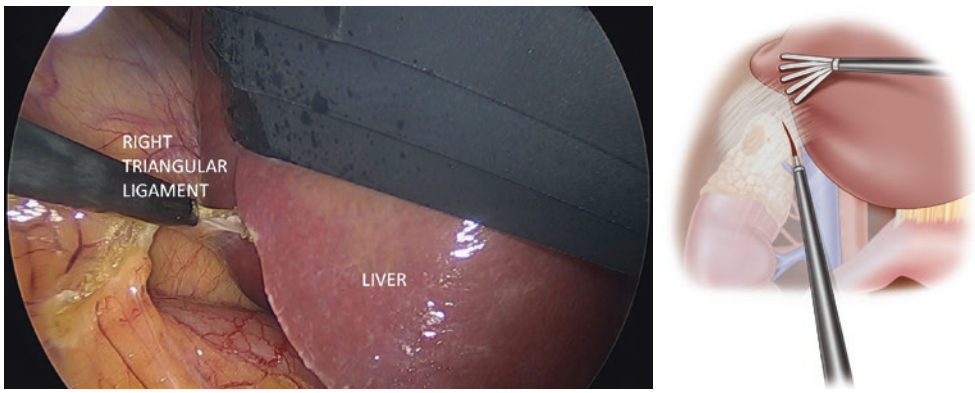


Fig. 2.3 The right triangular ligament is divided with hook electrocautery, and the liver is retracted with a fan retractor

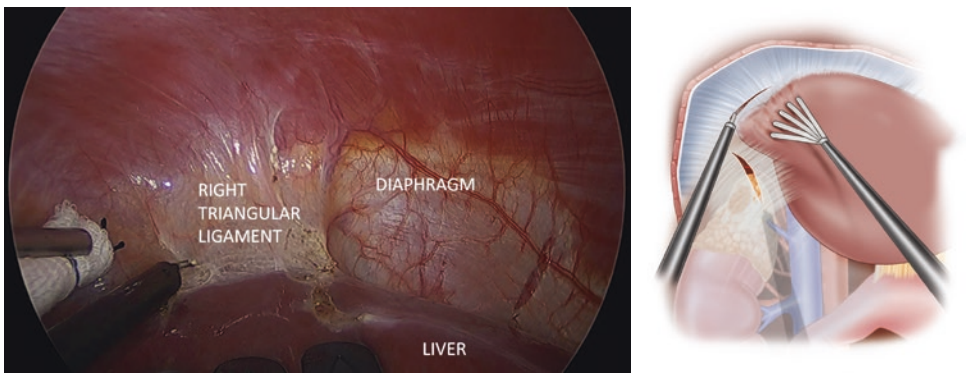


Fig. 2.4 Dissection of the right triangular ligament continues superiorly along the diaphragm

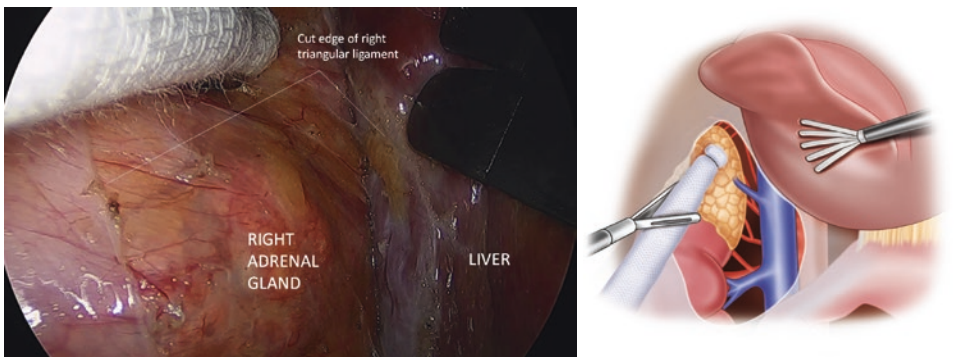


Fig. 2.5 The liver is retracted superiorly, exposing the right adrenal gland under the cut edge of the triangular ligament

with the LigaSure device. This frees up the cephalad aspect of the right adrenal gland and allows for better visualization of the right adrenal vein.

The right adrenal vein is then identified as it inserts into the inferior vena cava (IVC) (Fig. 2.7). The superior and inferior borders of the vein are dissected using blunt dissection and hook electrocautery. The adrenal gland is retracted laterally using rolled-up sponges, with care taken not to grasp the adrenal gland or tear the capsule. Once the vein is freed, the inferior vena cava side and the adrenal side of the vein are clipped (Fig. 2.8). A third clip is placed on the inferior vena cava side (Fig. 2.9). The right adrenal vein is divided with scissors, leaving two clips on the inferior vena cava side (Fig. 2.10). The dissection is then continued inferomedially toward the renal hilum. The middle adrenal arteries lie posterior to the adrenal vein and must be divided with electrocautery to avoid arterial bleeding (Fig. 2.11). As the dissection continues inferiorly, the inferior adrenal arteries are identified and divided with the LigaSure device (Fig. 2.12). Care is taken to avoid the superior renal artery and to identify any potential accessory adrenal vein.

A note on the adrenal arteries: while not often large, they are relatively consistent in their location, and anticipating where they are helps to keep the dissection bloodless. The superior artery comes toward the gland at the superiormedial aspect and almost always needs to be taken before the adrenal vein. The middle arteries are just behind the vein and are taken after the vein. These arteries have the potential to cause bleeding while dissecting the vein. The inferior artery is identified when the adrenal gland is retracted away from the

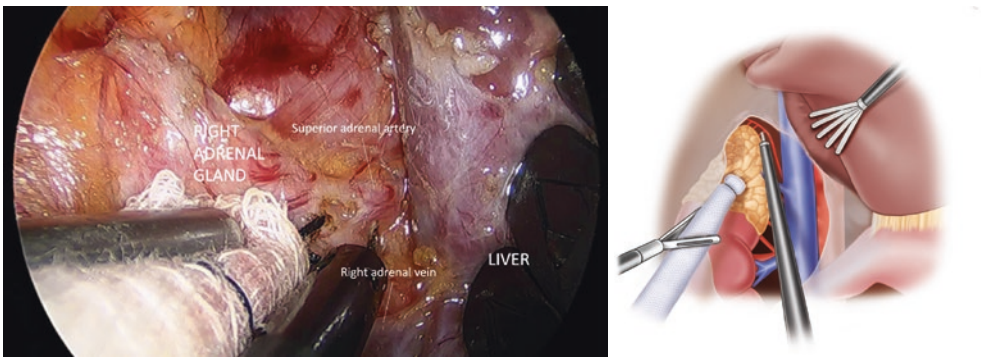


Fig. 2.6 The superior adrenal artery is identified as it enters the adrenal gland superiormedially

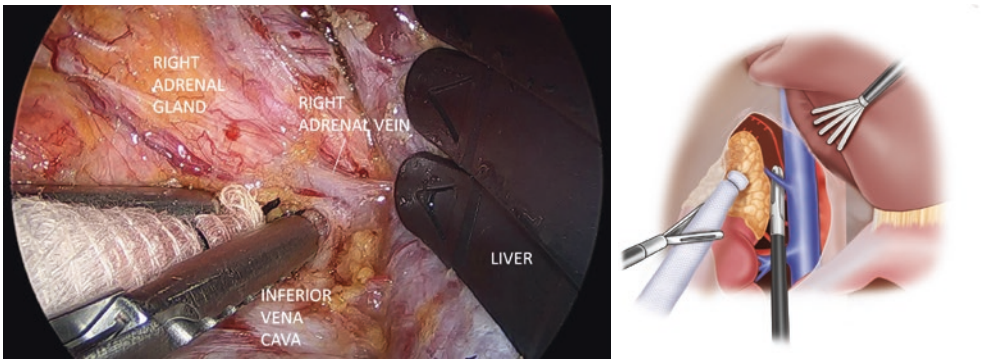


Fig. 2.7 The right adrenal vein is dissected at its insertion into the inferior vena cava using blunt dissection and electrocautery. The liver is being retracted using the fan retractor, and the adrenal gland is retracted using a rolled-up sponge

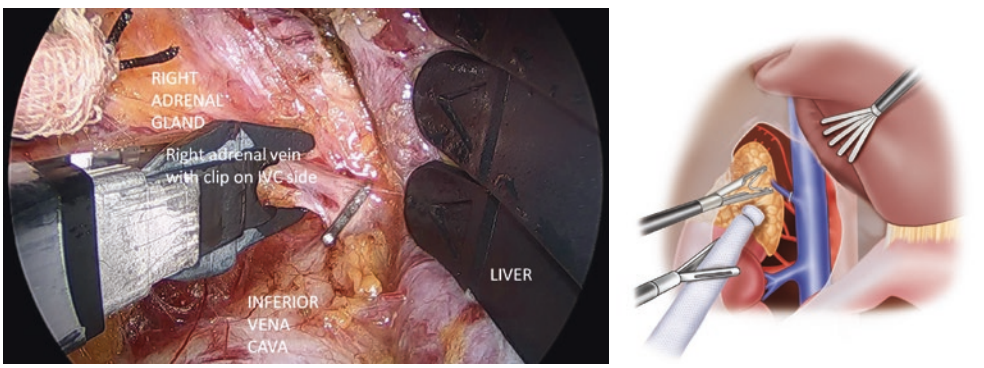


Fig. 2.8 The right adrenal vein is clipped on the inferior vena cava side. A second clip is being placed on the adrenal side

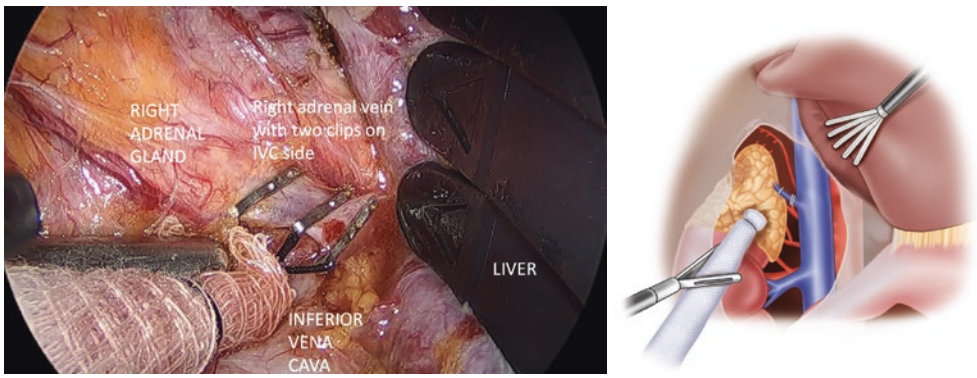


Fig. 2.9 Final placement of the clips with two clips on the inferior vena cava side and one clip on the adrenal gland side

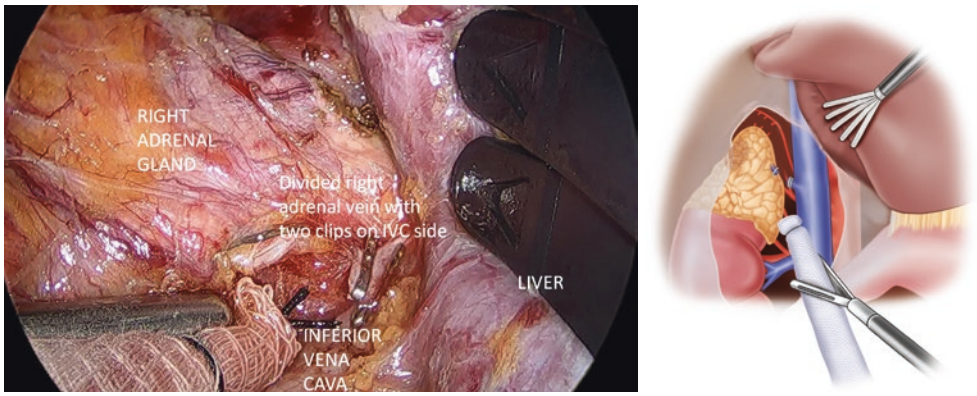


Fig. 2.10 The right adrenal vein has been divided, leaving two clips on the inferior vena cava side

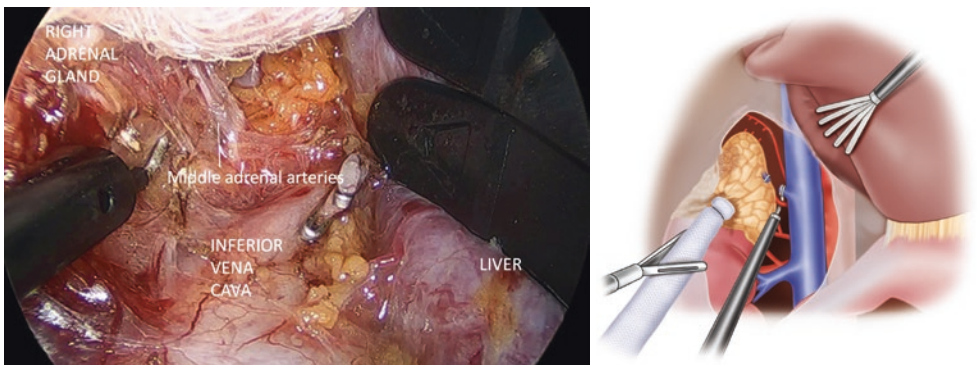


Fig. 2.11 The middle adrenal arteries are identified posterior to the adrenal vein and divided with electrocautery

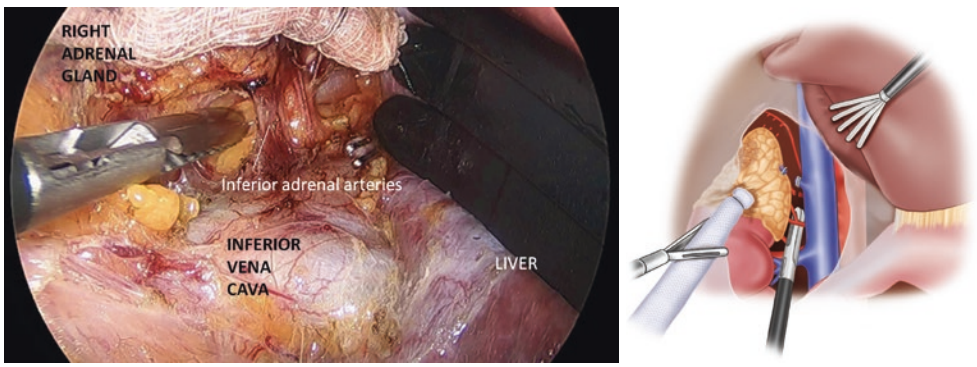


Fig. 2.12 As the dissection continues inferiorly toward the renal hilum, the inferior adrenal arteries are dissected and divided

renal hilum. Once this artery is taken, the gland is freed from the renal hilum. The three sets of arteries are like three sets of "springs" that hold the gland to the liver, IVC, and kidney. As they are taken, the gland is freed first superiormedially from the liver, then medially from the IVC, and then inferiorly from the renal hilum.

The dissection is then continued inferiorly. The flattened portion of the right adrenal gland is dissected and freed from its attachments to the kidney (Fig. 2.13). The LigaSure device is used to seal any small adrenal vessels that may be in the perirenal fat (Fig. 2.14). The dissection is continued until the adrenal gland is free from its attachments and muscle is visualized posteriorly. The adrenal gland is placed aside, and the area is irrigated and examined to ensure adequate hemostasis (Fig. 2.15). The gland is then placed in a laparoscopic bag and removed through the lateral-most port, which is port #1 (Fig. 2.16). The adrenal fossa is inspected again, and the trocars are removed under direct vision. The port sites from dilating 11-mm trocars do not require fascial closure. The skin is closed with subcuticular suture and skin glue.

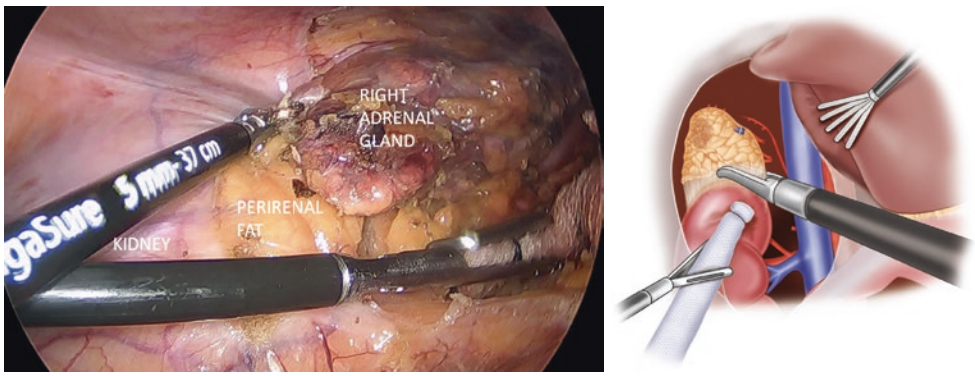


Fig. 2.13 The right adrenal gland is dissected off the superior pole of the kidney, using the LigaSure device to seal small adrenal vessels

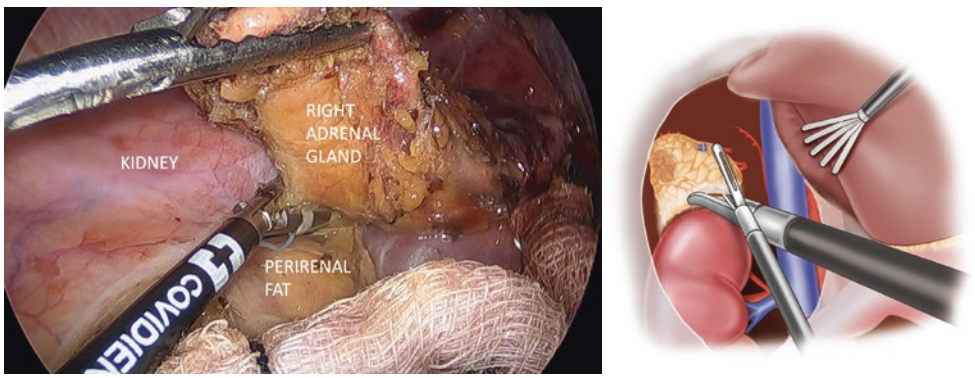


Fig. 2.14 The right adrenal gland is dissected from the superior pole of the kidney with muscle seen posteriorly

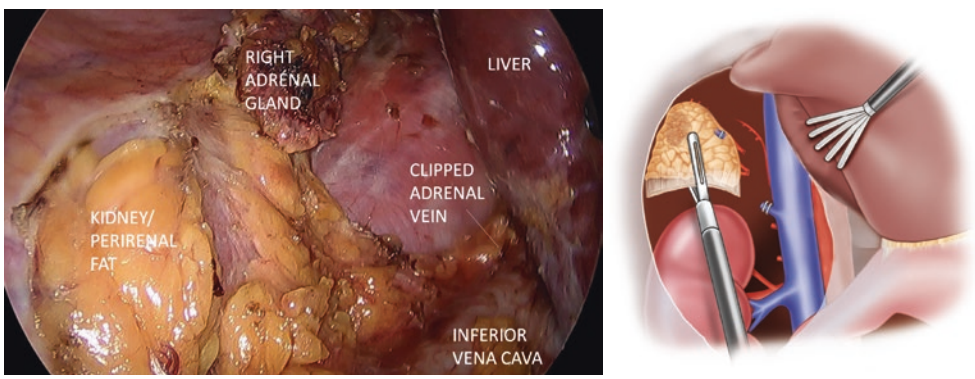
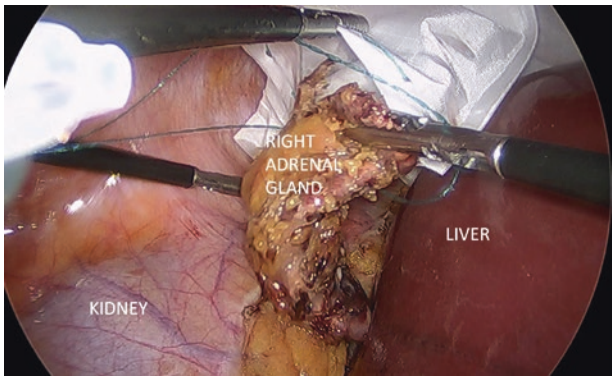


Fig. 2.15 The right adrenal gland is placed aside, and the adrenal fossa is irrigated and examined to ensure hemostasis



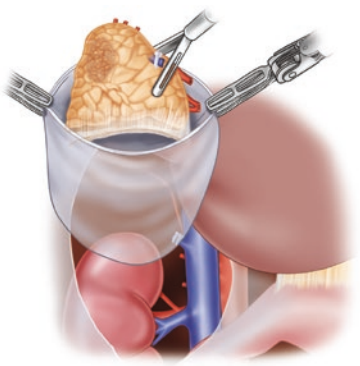


Fig. 2.16 The right adrenal gland is placed in a laparoscopic bag and removed through the lateral port

Suggested Reading

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Laparoscopic Transabdominal Right Adrenalectomy

3

Timo W. Hakkarainen and William B. Inabnet III

Laparoscopic adrenalectomy via a transabdominal lateral approach is a well-established, safe technique to remove either left or right adrenal. It is generally indicated for all benign functioning lesions of the adrenal gland that measure less than 6 cm. The most common lesion in this category is a cortisol-secreting adenoma, followed by aldosterone-secreting adenoma, nonfunctional lesions between 4 and 6 cm, or benign-appearing lesions that demonstrate interval growth on cross-sectional imaging. This approach is also safe for pheochromocytomas that do not manifest features worrisome for malignancy (metastatic disease, invasion of adjacent tissue). Typically, pheochromocytomas greater than 8 cm have been recommended to be resected with an open approach, but in the absence of worrisome features, this size limit is subject to the technical expertise and experience of the surgeon.

Preoperative Considerations

- High-quality cross-sectional adrenal imaging with multiphase CT or MRI is mandatory in the diagnostic process, as well as for surgical planning.
- We routinely screen all patients with an adrenal lesion—regardless of their symptomatology—for pheochromocytoma with plasma metanephrines and normetanephrines.
- If hyperaldosteronism is suspected—and given the relatively high incidence of nonfunctional adrenal adenomas and the classically small size of aldosterone-secreting lesions—we routinely utilize selective adrenal venous sampling to confirm laterality in all patients over the age of 40 and maintain a low threshold for its use in younger patients.

Laparoscopic Right Adrenalectomy Surgical Technique

Pearls and Pitfalls

- Early mobilization of the lateral attachments of the liver allows for more effective retraction of the liver without capsular tears. It is also important to divide superior attachments between the peritoneum overlying the right adrenal gland from the liver early, to prevent similar capsular tears and bleeding that can obscure the operative field.
- Careful dissection between the inferior vena cava (IVC) and the right adrenal gland early on minimizes traction on the IVC as the gland is retracted and prevents injury to the IVC.
- In patients with significant intraabdominal fat that obscures the adrenal gland, dissection along the IVC can identify the right renal vein. Once this is performed, the dissection can proceed superiorly along the capsule of the kidney, removing all periadrenal tissue with the gland. This is safer than attempting to identify the adrenal gland within the retroperitoneal fat, which poses the risk of inadvertently transecting a portion of the adrenal gland (Figs. 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, and 3.15).

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A. Shifrin (ed.), *Atlas of Adrenal Surgery*, https://doi.org/10.1007/978-3-030-01787-3_3

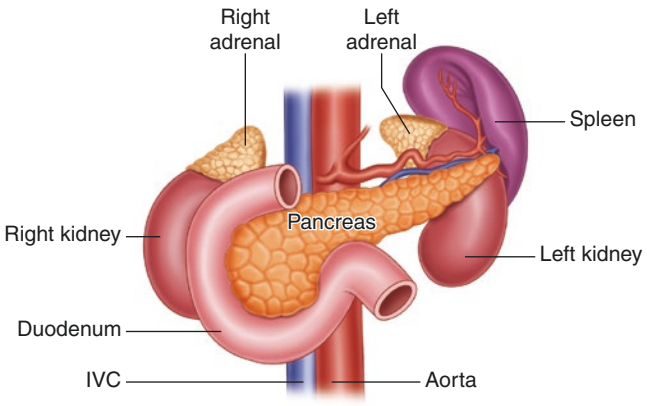


Fig. 3.1 The overlying anatomic relationship between the adrenal glands, major vascular structures, and other retroperitoneal organs can be appreciated here. The adrenal glands lie superior to the ipsilateral kidney in the retroperitoneum. The right adrenal gland lies behind the right lobe of the liver along the posterior aspect of the IVC

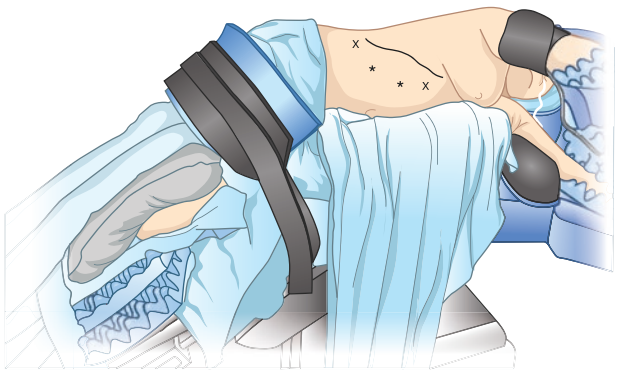
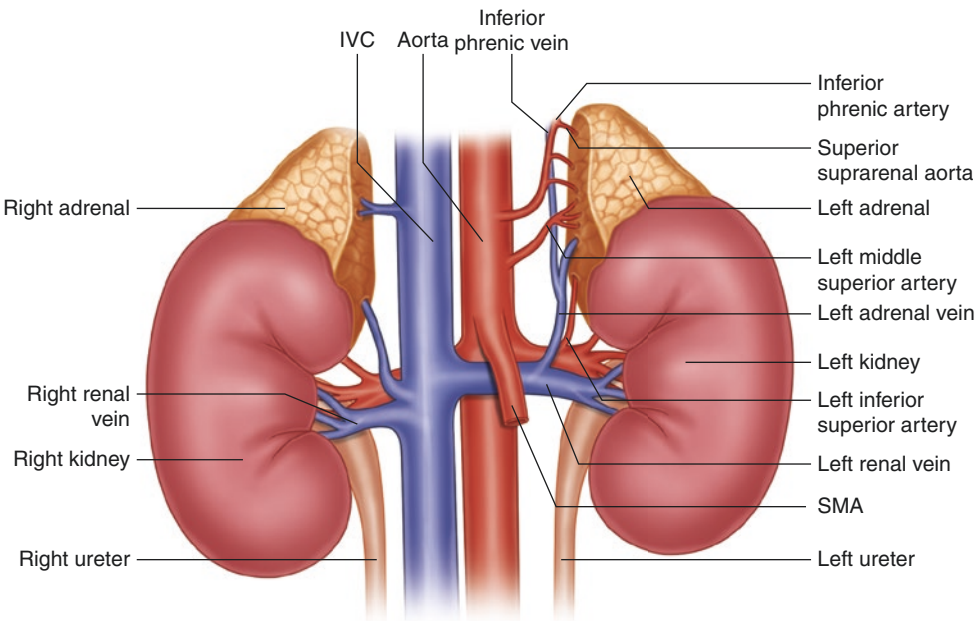


Fig. 3.3 The patient is positioned in a right lateral decubitus position, with the bed flexed to extend the space between the inferior aspect of the ribs and the iliac crest. Care must be taken to appropriately pad the patient and to provide support to prevent the patient from shifting when the operative table is tilted. The patient is prepped from table edge to edge and from the iliac crest up to a level above the xiphoid. Ports are placed 2–3 fingerbreadths below the right costal margin. The ports marked with an asterisk are typically 10-mm ports; the ports marked with an X are typically 5-mm ports

Fig. 3.2 The right adrenal gland lies along the posterior aspect of the IVC. It typically has a single short adrenal vein draining directly into the IVC; however, there can be accessory veins draining into the IVC or into the right renal vein



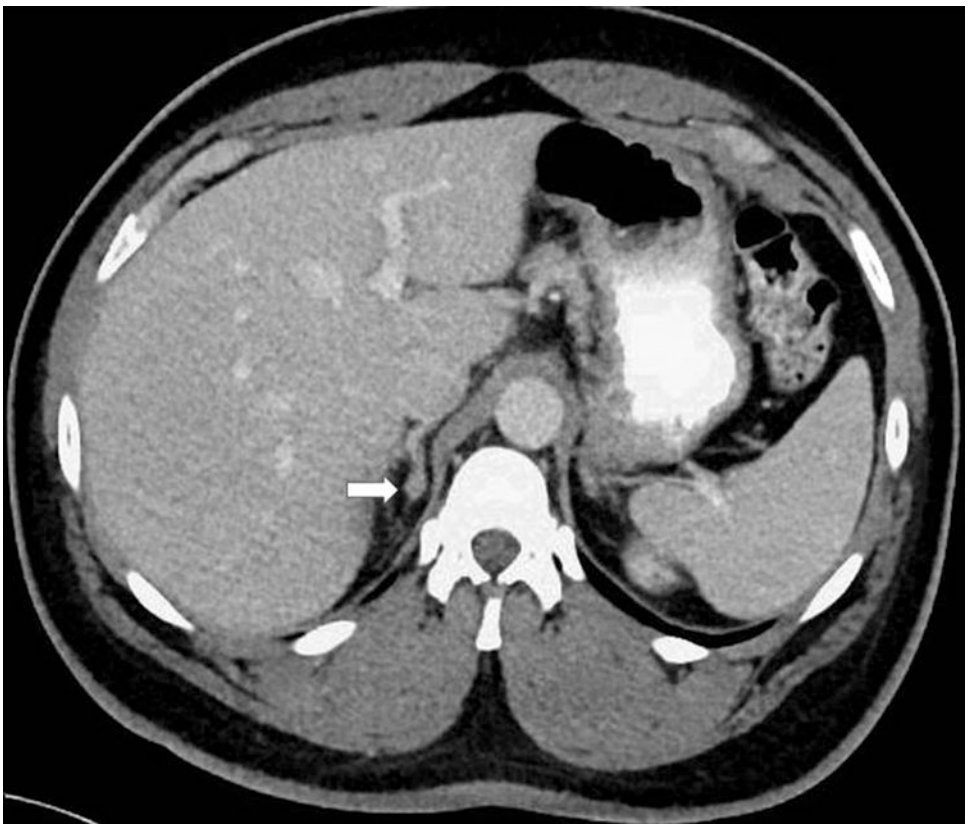


Fig. 3.4 The patient is a 43-year-old with refractory hypertension and mild persistent hypokalemia who was found to have elevated aldosterone with suppressed renin. Cross-sectional imaging of the abdomen demonstrates a 1-cm right adrenal nodule consistent with an adenoma (*white arrow*). Selective venous sampling confirmed elevated aldosterone secretion from the right adrenal gland

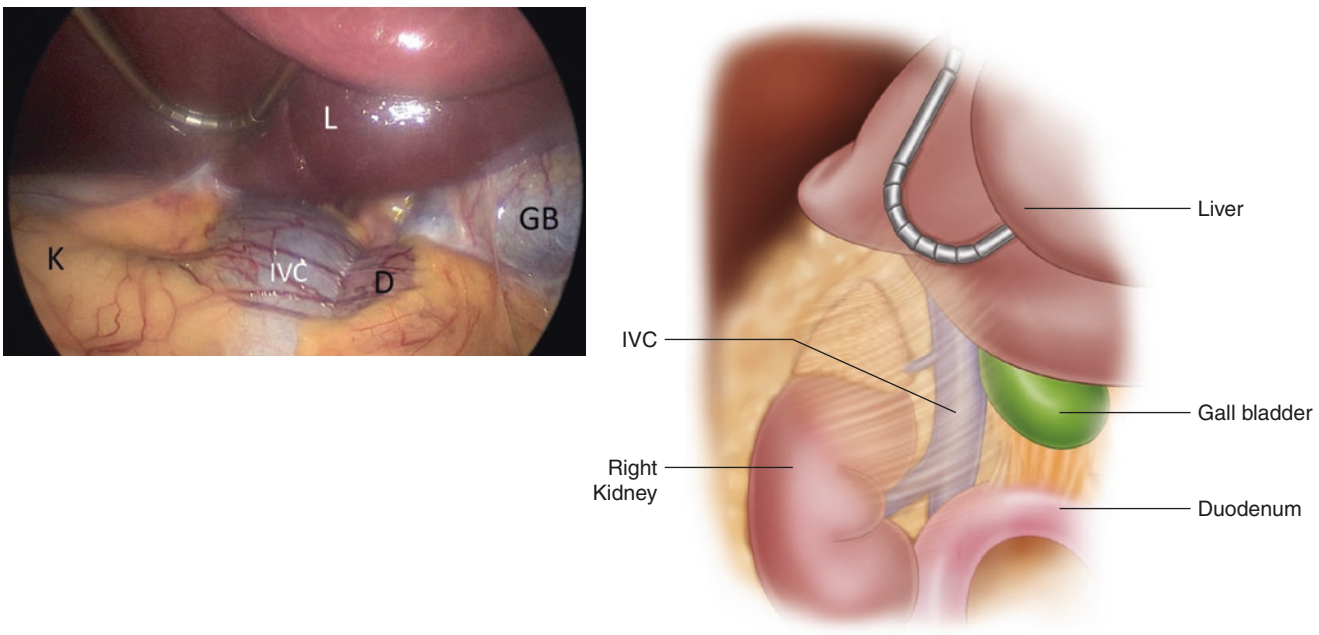


Fig. 3.5 A liver retractor is placed through the sub-xiphoid port and used to retract the liver superiorly, exposing the second portion of the duodenum, IVC, right kidney, and right adrenal gland

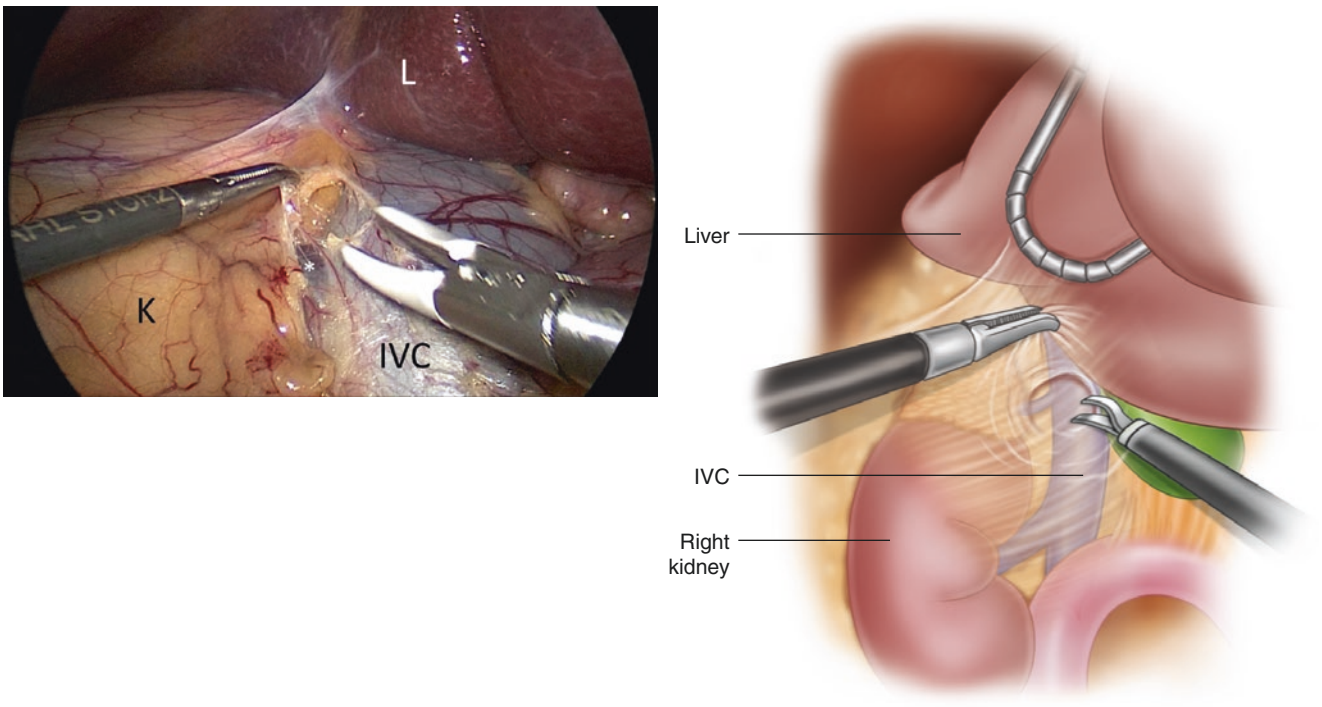


Fig. 3.6 The peritoneum investing the right kidney, right adrenal gland, and IVC is then carefully incised. This plane of dissection will be followed superiorly and laterally to free the adrenal gland from the inferior-posterior aspect of the liver. Care should be taken not to ligate and divide major vessels until the anatomy is clearly delineated. Careful review of the preoperative imaging identified an accessory right renal vein (identified here) that could easily be mistaken for the right adrenal vein

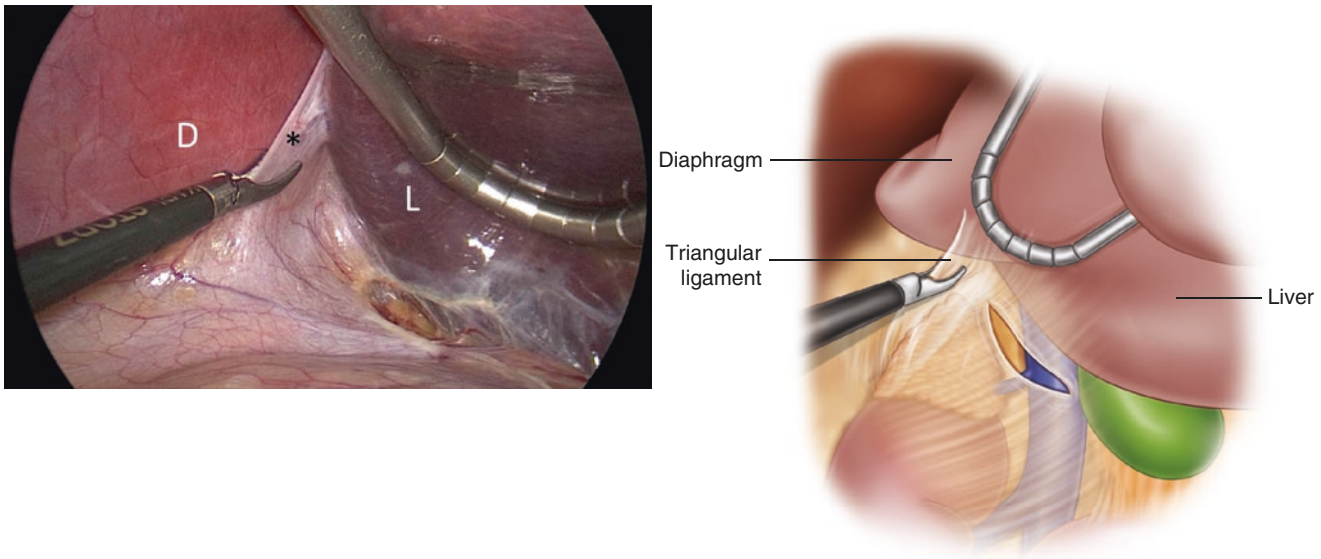


Fig. 3.7 The right triangular ligament of the liver can be divided to allow tension-free retraction of the liver and avoid capsular tears. Care should be taken to avoid injuring the diaphragm

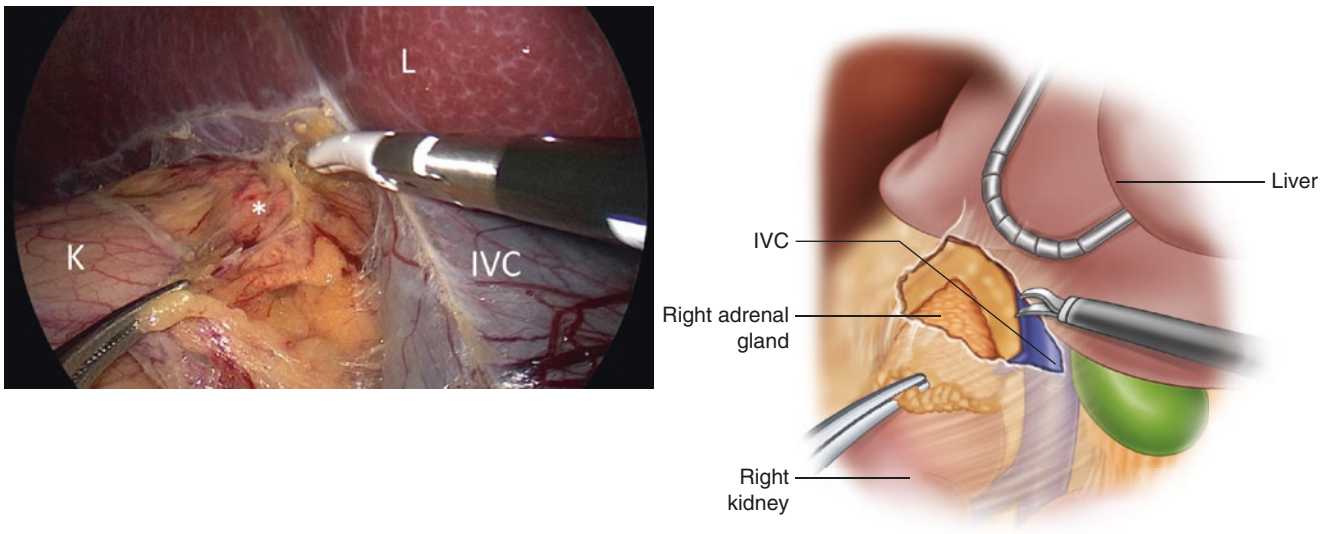


Fig. 3.8 The right adrenal gland is exposed (identified by its golden-yellow hue) and carefully dissected away from the liver superiorly. The adrenal gland should not be grasped directly. Periadrenal fat and the investing peritoneum should be used for retraction to avoid tearing the adrenal capsule

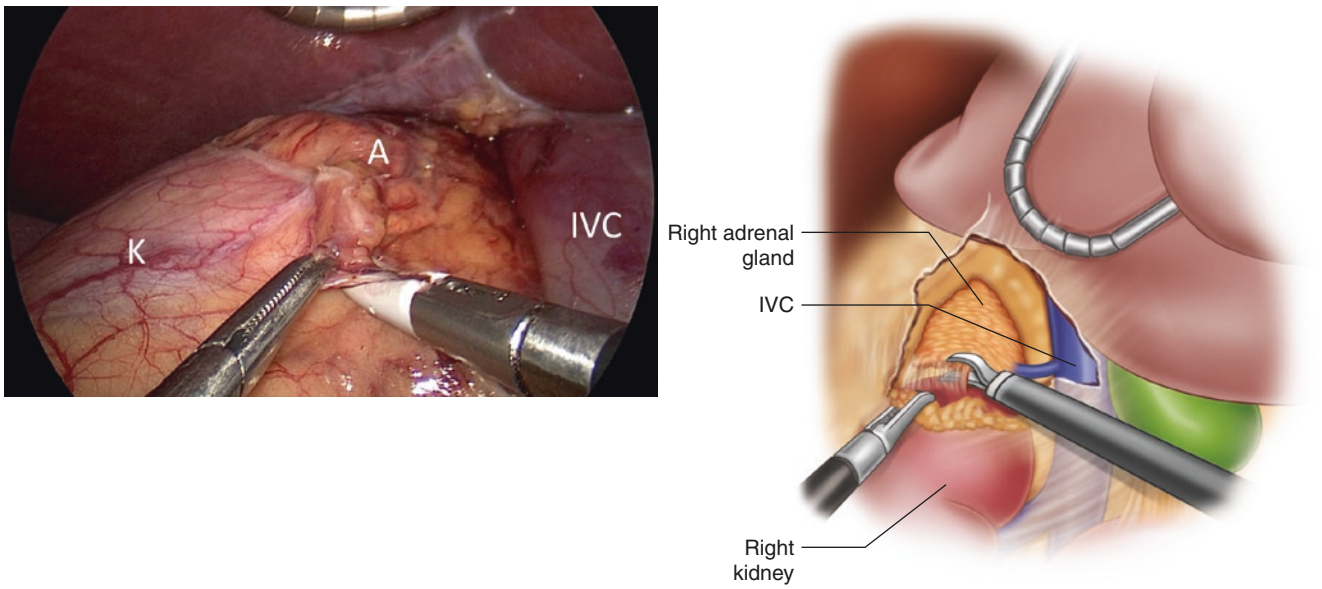


Fig. 3.9 The inferior aspect of the adrenal gland is dissected away from the superior pole of the right kidney. The correct line can be identified by gently grasping the peritoneum and watching the adrenal gland and investing tissue slide across the underlying kidney

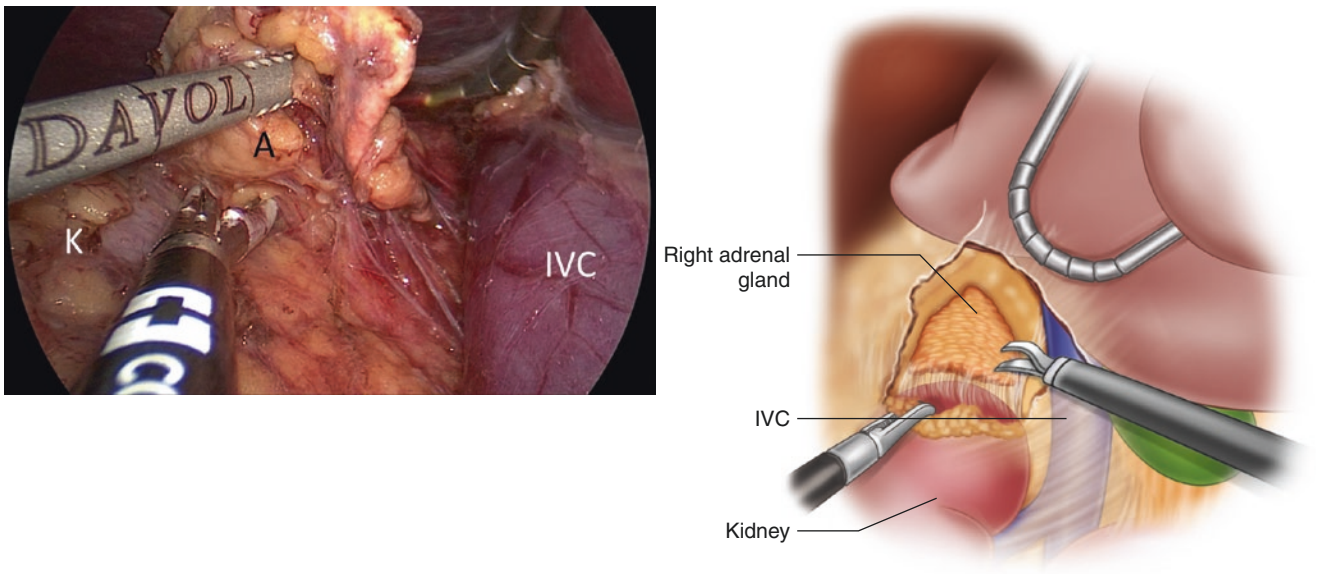


Fig. 3.10 The right adrenal gland is then carefully dissected off the superior pole of the right kidney, and this dissection is carefully extended medially and along the inferior vena cava

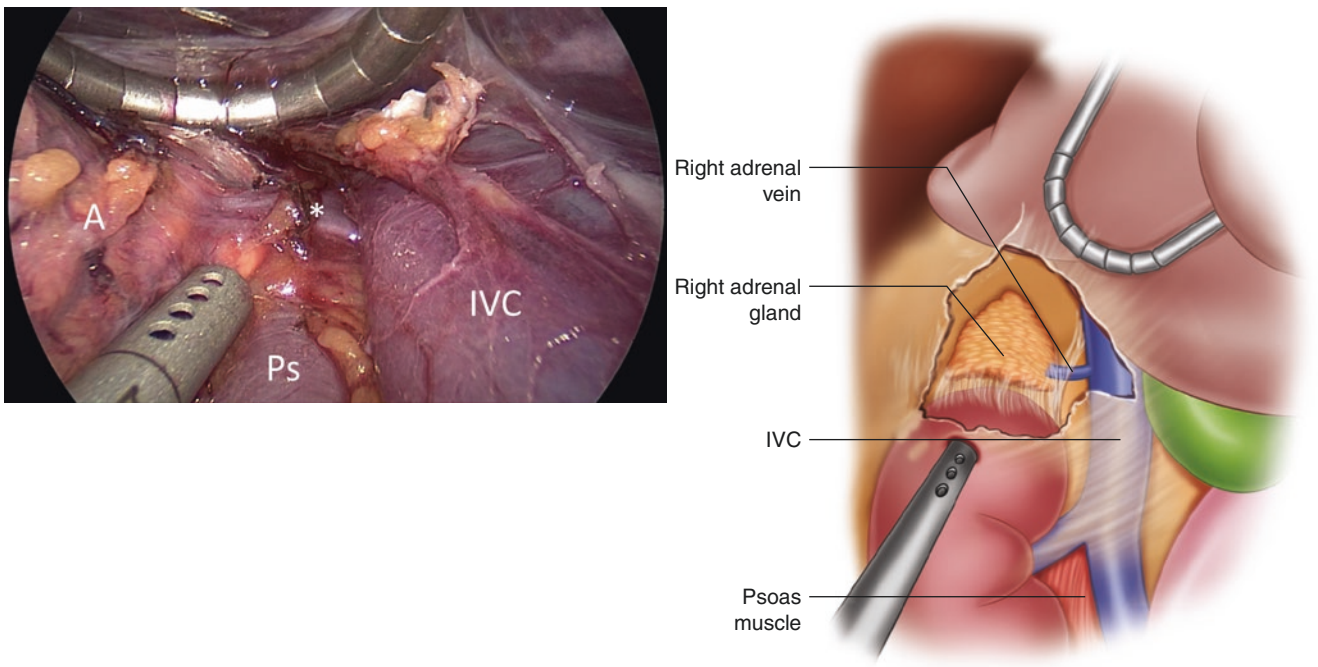


Fig. 3.11 Further careful dissection along the medial aspect of the adrenal gland identifies the right adrenal vein branching directly off the inferior vena cava, usually along the posterior aspect

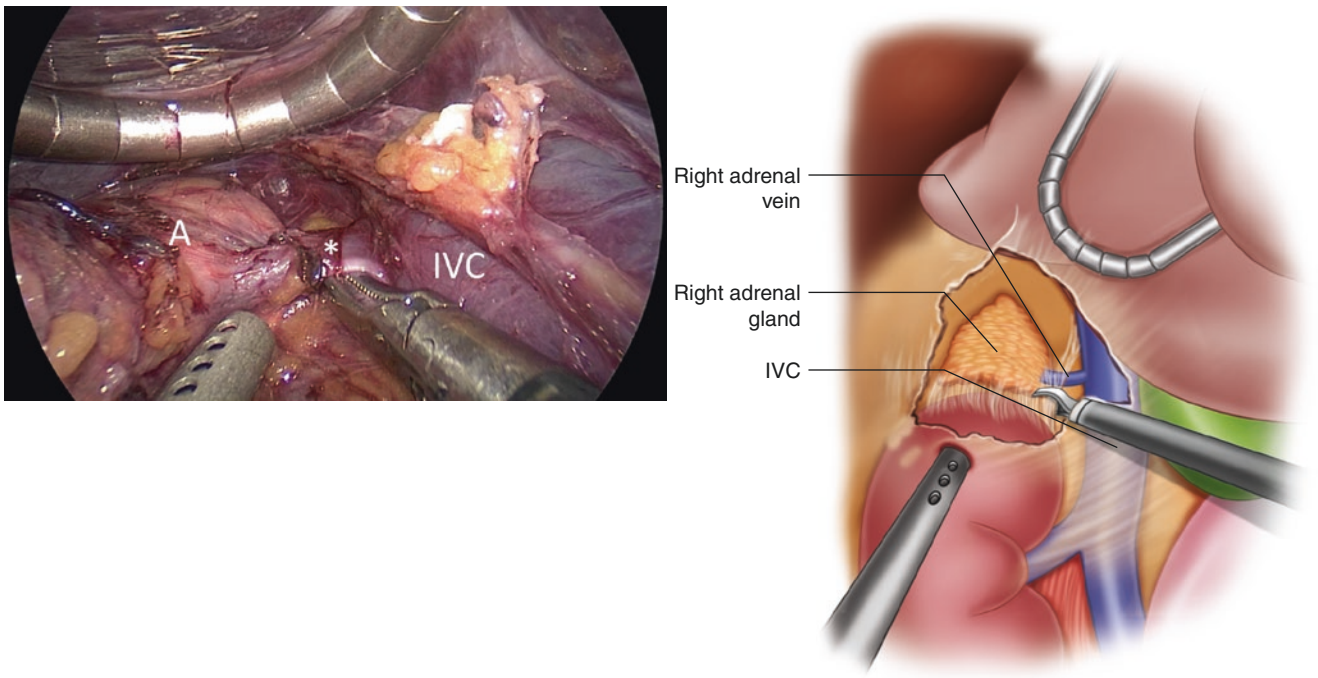


Fig. 3.12 The right adrenal vein is carefully circumferentially dissected, which allows greater length along the vessel for safe ligation and division

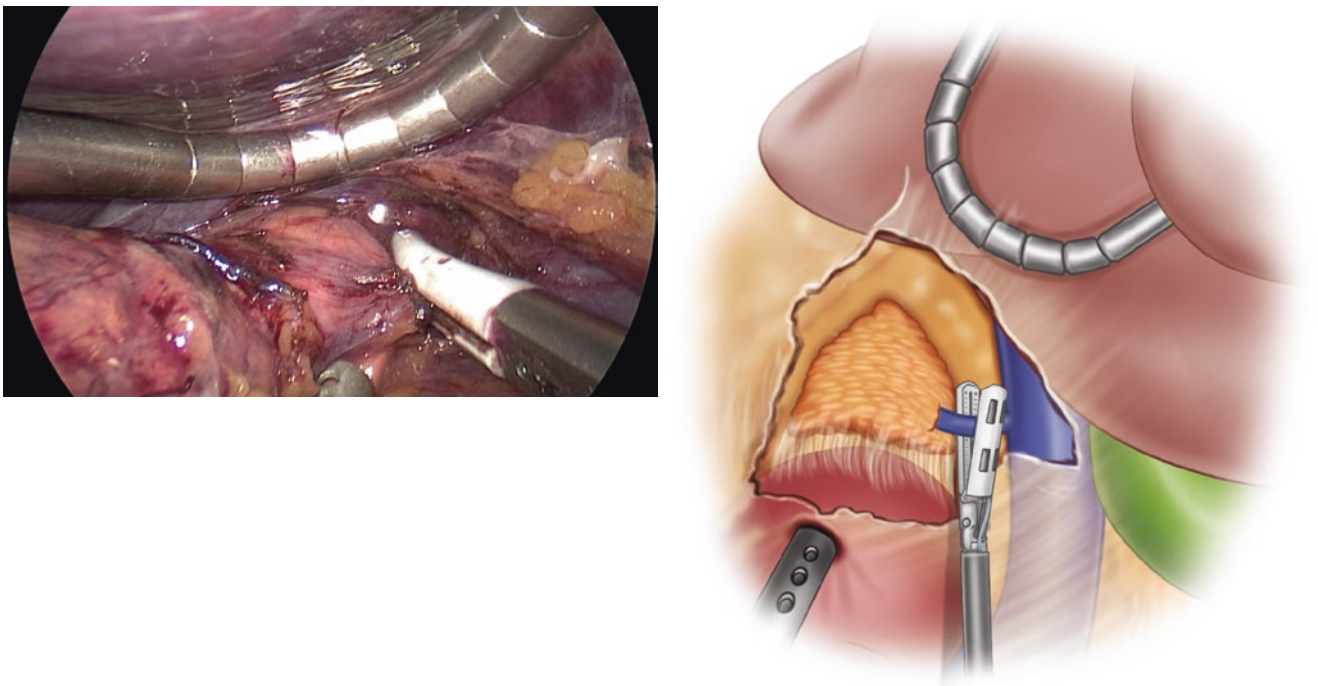


Fig. 3.13 The right adrenal vein can be ligated and divided using a vessel-sealing energy device or between clips. Care must be taken to avoid injury to the confluence of the adrenal vein and inferior vena cava, and bleeding from such an injury can be extremely difficult to control

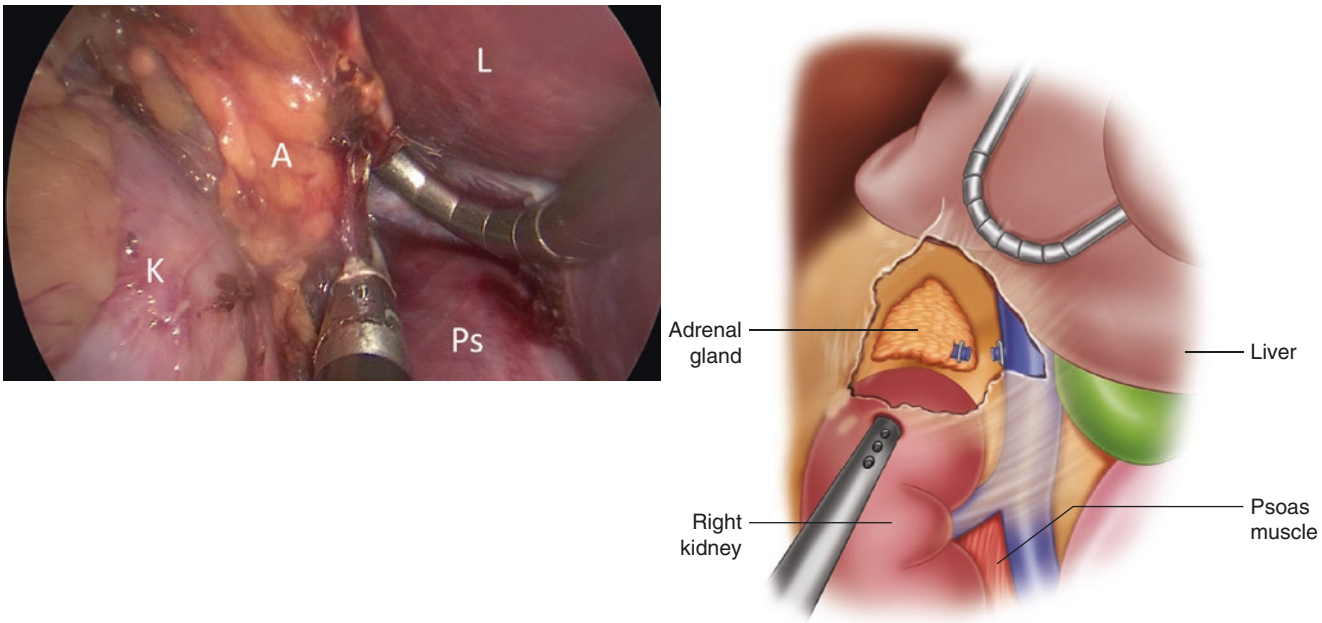


Fig. 3.14 Once the right adrenal vein is divided, the adrenal gland and investing tissue are elevated off the underlying psoas muscle, and the remainder of the attachments to the retroperitoneum and superior pole of the right kidney is divided. Once the gland is free, it is removed with an endoscopic specimen retrieval bag through one of the subcostal ports

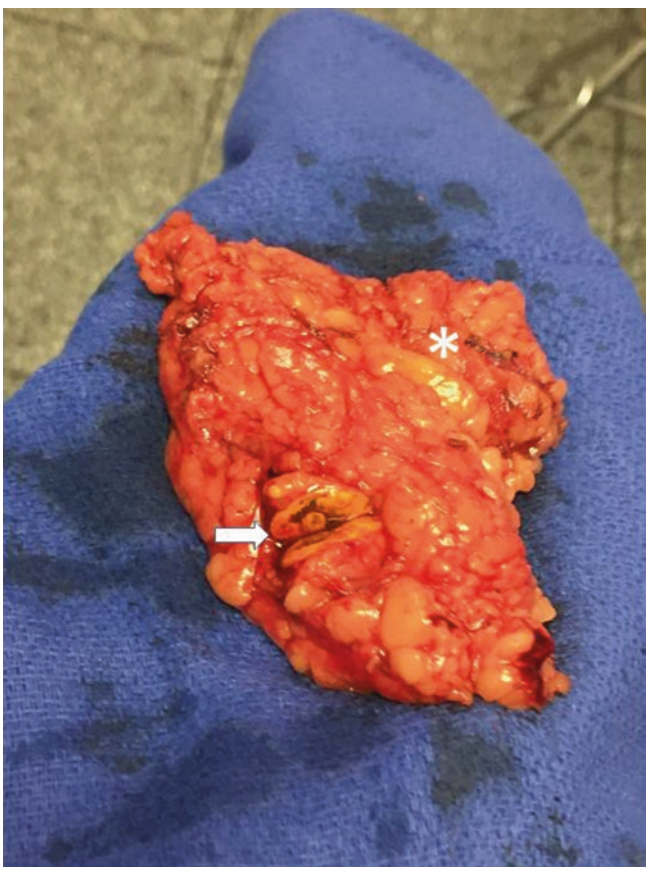


Fig. 3.15 The 1 cm aldosteronoma (*white arrow*) can be seen incised after removal. No other violation of the adrenal capsule was found. The ligated stump of the right adrenal vein (*asterisk*) can be seen at the superior aspect of the gland

Suggested Reading

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Laparoscopic Transabdominal Left Adrenalectomy

4

Timo W. Hakkarainen and William B. Inabnet III

Introduction

The general guidelines, indications for adrenalectomy, and preoperative considerations described in Chap. 3 are equally applicable for left-sided adrenal lesions. The dissection plane between the adrenal gland and the splenic hilum, including splenic vessels and tail of pancreas, is typically much less distinct than dissection on the right, and care must be taken to avoid injury to the structures mentioned. The tail of the pancreas and splenic vessels are particularly susceptible to injury. (See Figs. 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, 4.14, 4.15, 4.16, and 4.17 and Video 4.1 for details.)

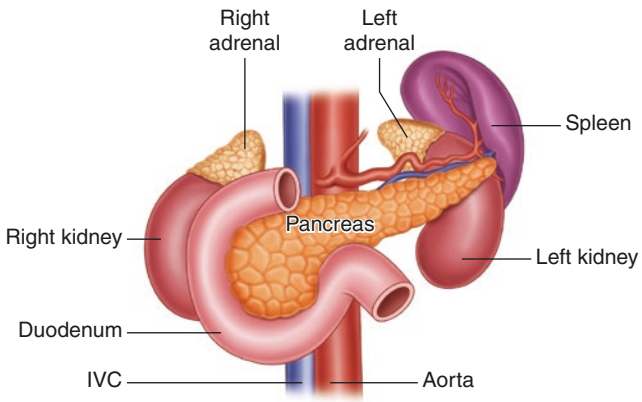

Fig. 4.1 The overlying anatomic relationship between the adrenal glands, major vascular structures, and other retroperitoneal organs can be appreciated here. The adrenal glands lie superior to the ipsilateral kidney in the retroperitoneum. The left adrenal gland lies behind the tail of the pancreas and splenic hilum, just lateral to the aorta

Laparoscopic Left Adrenalectomy Surgical Technique

Pearls and Pitfalls

- The splenic flexure of the colon should be mobilized early and well below the level of the renal hilum. Doing so allows the colon to fall out of the operative field and minimizes the risk of colon injury. It also allows better visualization of the renal hilum when identifying the left renal vein.
- All attachments to the spleen should be divided early to allow retraction of the spleen without capsular tears, which cause bleeding and obscure the operative field.
- The plane of dissection between the tail of the pancreas and the retroperitoneum can be indistinct, and it is easy to inadvertently injure the tail of the pancreas or dissect too deep and encounter bleeding in the retroperitoneum. We find it helpful to frequently return to the inferior-most dissection and begin again at the easily identified plane between Gerota's fascia on the kidney and the mesocolon. This more consistently allows identification of the correct avascular plane as you continue superiorly.
- In patients with large amounts of intraabdominal fat, careful dissection along the capsule of the kidney medially allow identification of the left renal vein, inferior phrenic vein, and left adrenal vein. Once these are identified, the left adrenal vein can be divided, and the dissection can proceed along the capsule of the kidney, removing all periadrenal tissue. As on the right, this en bloc removal of the adrenal gland with surrounding adipose tissue is safer and decreased the risk of inadvertently transecting the adrenal gland.

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_4) contains supplementary material, which is available to authorized users.

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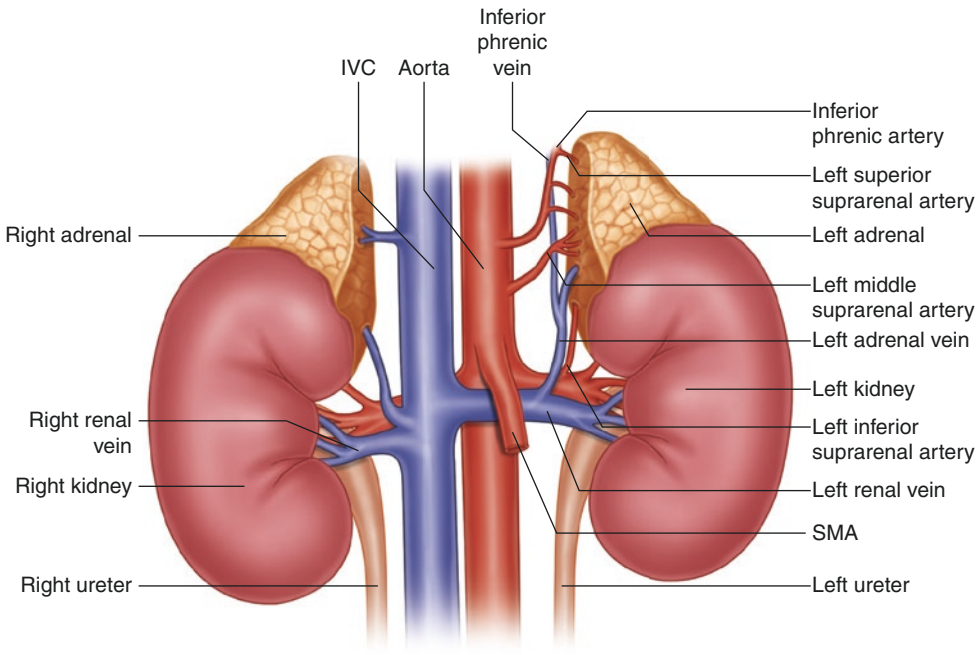


Fig. 4.2 The left adrenal gland lies along the lateral aspect of the aorta. It typically has a single, vertically oriented adrenal vein draining in the left renal vein. It can either converge with the left inferior diaphragmatic vein before joining the left renal vein, or these two veins can run parallel and enter the left renal vein separately

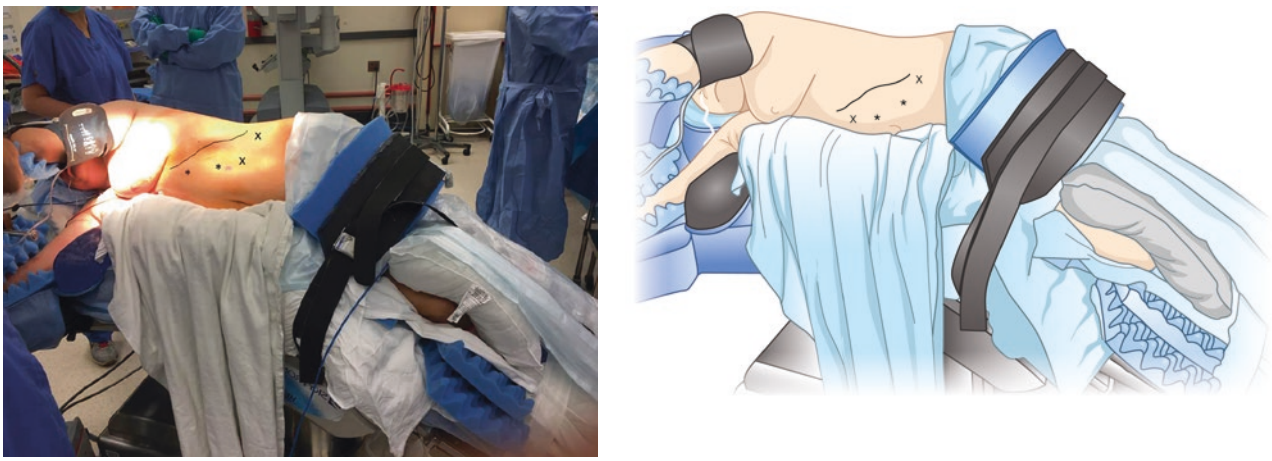


Fig. 4.3 The patient is positioned in a left lateral decubitus position, with the bed flexed to extend the space between the inferior aspect of the ribs and the iliac crest. Care must be taken to appropriately pad the patient and to provide support to prevent the patient from shifting when the operative table is tilted. The patient is prepped from table edge to edge and from the iliac crest up to a level above the xiphoid. For a left adrenalectomy, the positioning is in the left lateral decubitus position, and port placement is nearly a mirror image for that of a right adrenalectomy. Ports are placed 2–3 fingerbreadths below the left costal margin. The ports marked with an asterisk are typically 10-mm ports, and the ports marked with an X are typically 5-mm ports

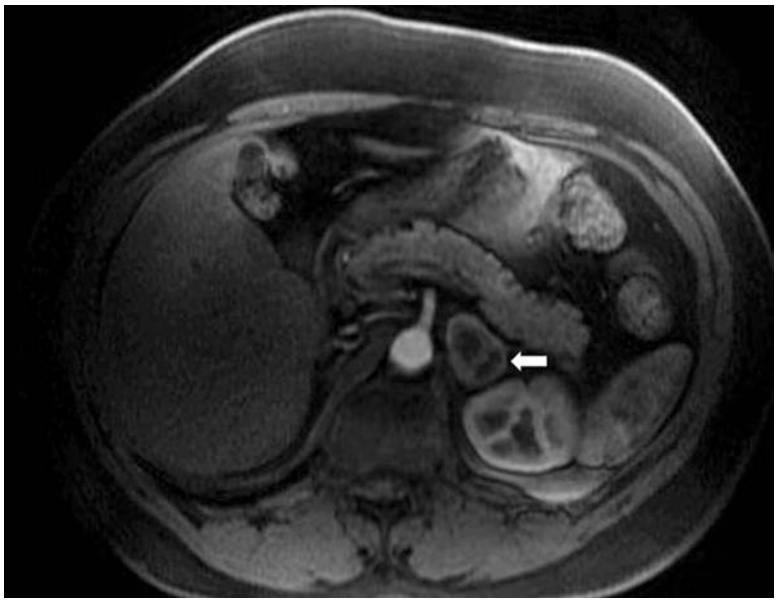


Fig. 4.4 The patient is a 51-year-old woman with long-standing diabetes who was noted to have progressively difficult-to-control blood sugar after many years on a stable regimen and no changes to her health or diet. Upon further evaluation she was also noted to have episodic palpitations. She was found to have elevated plasma metanephrines and normetanephrines and on cross-sectional imaging was found to have a 4-cm left adrenal mass consistent with a pheochromocytoma

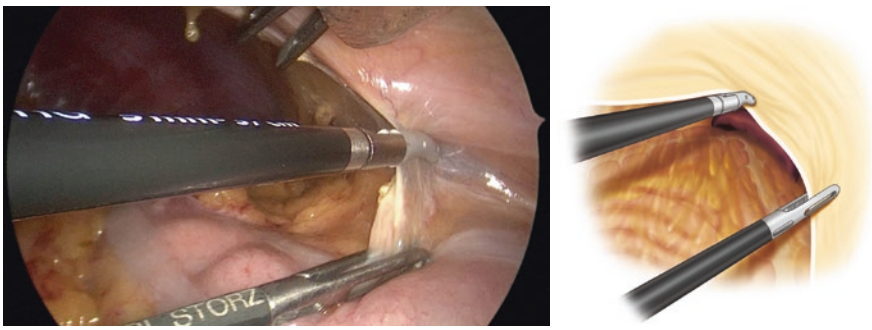
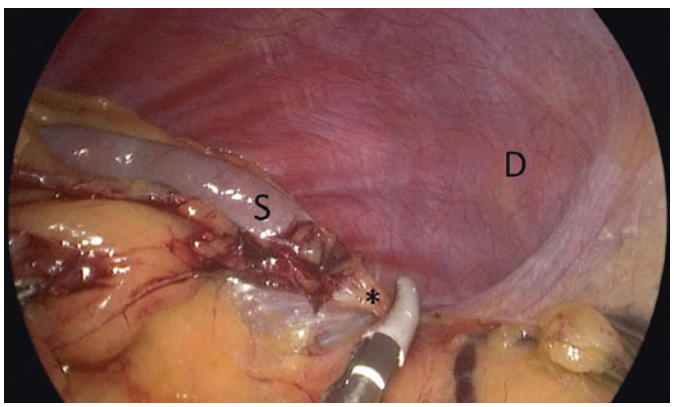


Fig. 4.5 The left colon is seen across the bottom of the view here. It is carefully retracted away from the abdominal wall, and the peritoneal reflection along the lateral aspect is incised to allow mobilization of the colon and easier exposure of the superior pole of the kidney and left adrenal gland



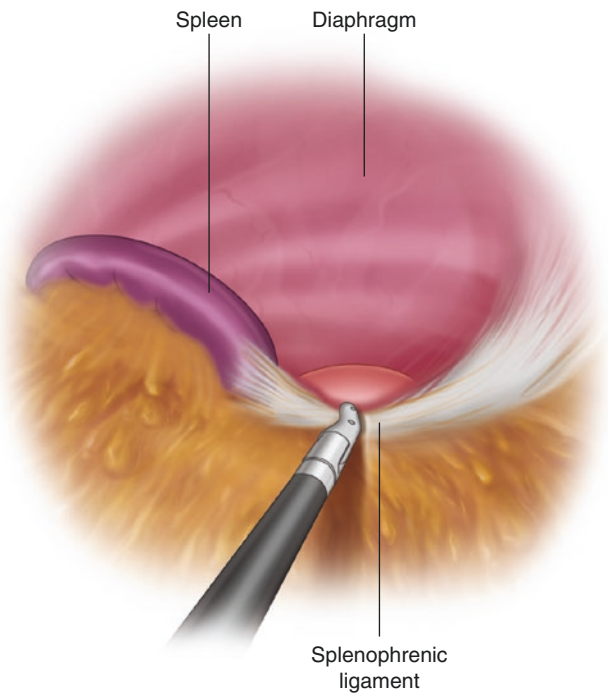


Fig. 4.6 The splenophrenic ligament is incised, which allows medialization of the spleen. Care should be taken to avoid damage to the splenic capsule. Mobilization of the spleen until the gastric fundus is visualized superiorly insures sufficient mobility of the spleen to fully visualize the left adrenal gland

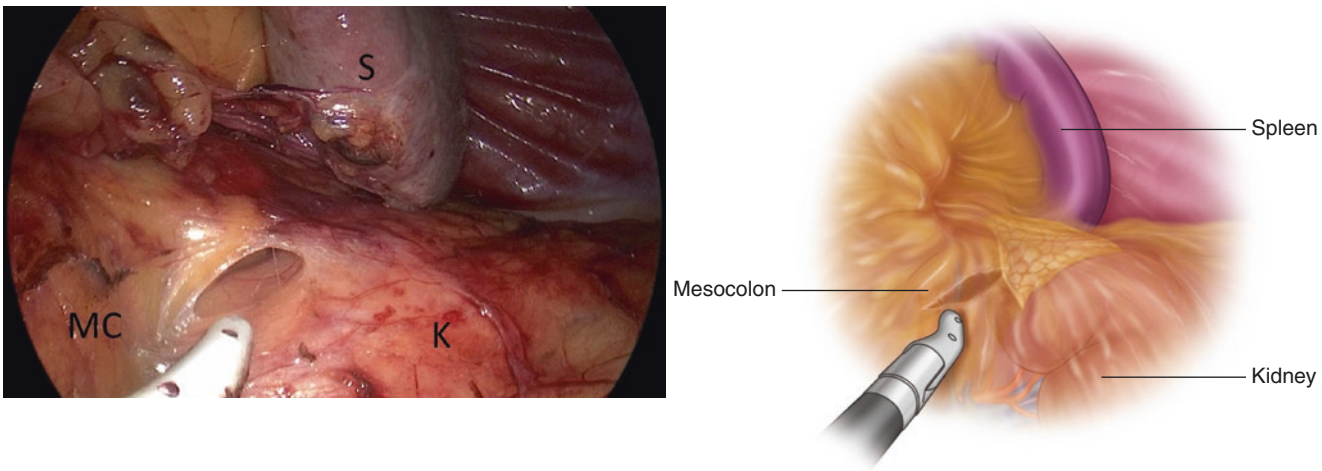


Fig. 4.7 The spleen is medialized, and the loose areolar attachments between the left mesocolon and Gerota's fascia investing the kidney are placed on gentle traction and divided. This plane is followed superiorly—layer by layer—frequently returning to the confluence of the mesocolon and Gerota's fascia to ensure the correct plane of dissection is followed

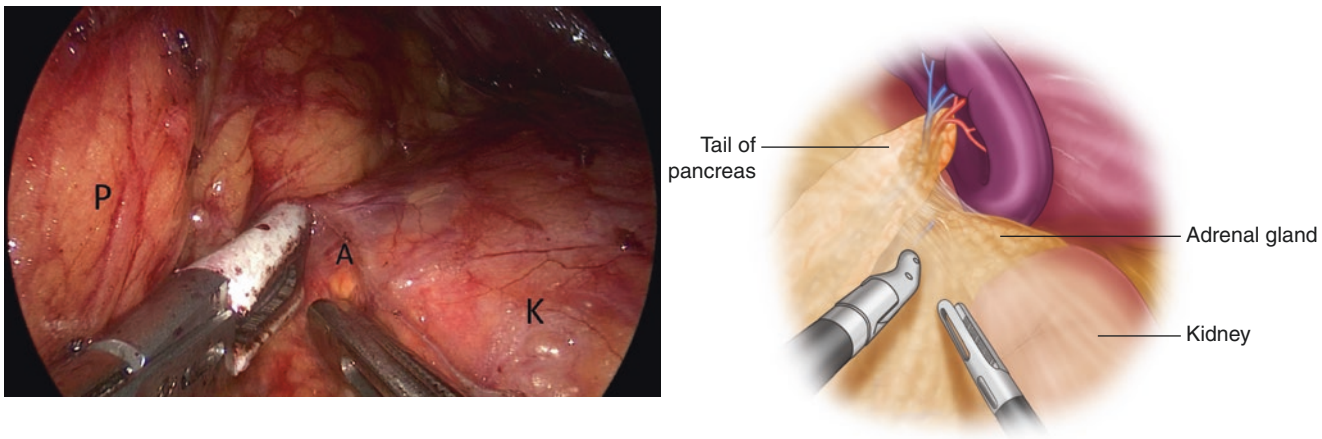


Fig. 4.8 As the dissection proceeds superiorly, the mesocolon on the left is replaced by the tail of the pancreas, splenic vessels, and investing fat. The tail of the pancreas can be seen on the left here reflecting superiorly, with the left adrenal beginning to become apparent on the right. Care must be taken to avoid injury to the tail of the pancreas by following the correct plane of dissection

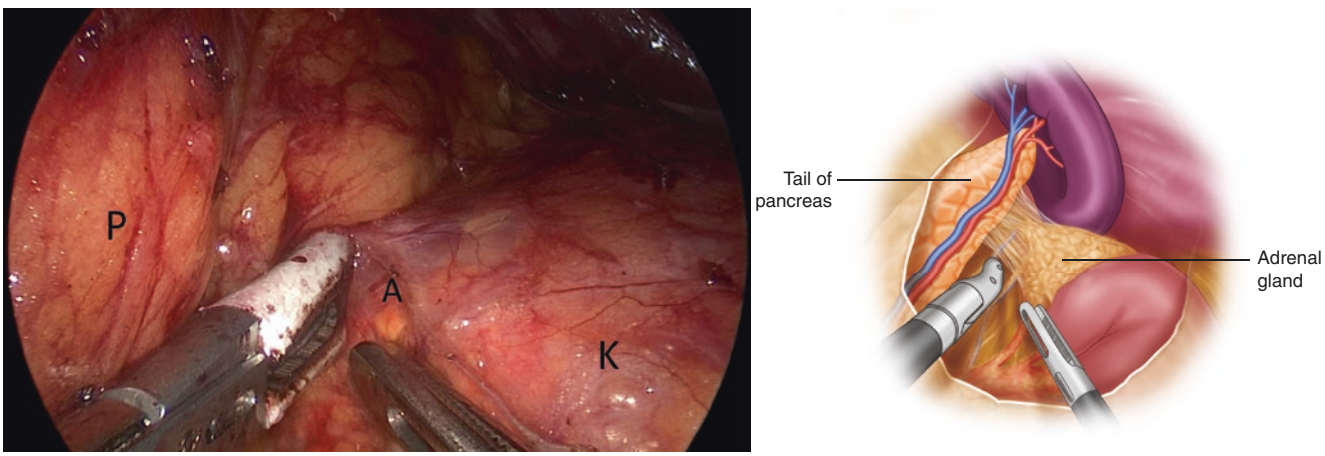


Fig. 4.9 The medial aspect of the adrenal gland (identified by its slightly golden hue) is carefully dissected away from the tail of the pancreas. Care must be taken as the splenic vein and artery are often exposed near the tail of the pancreas during this dissection and can easily be injured

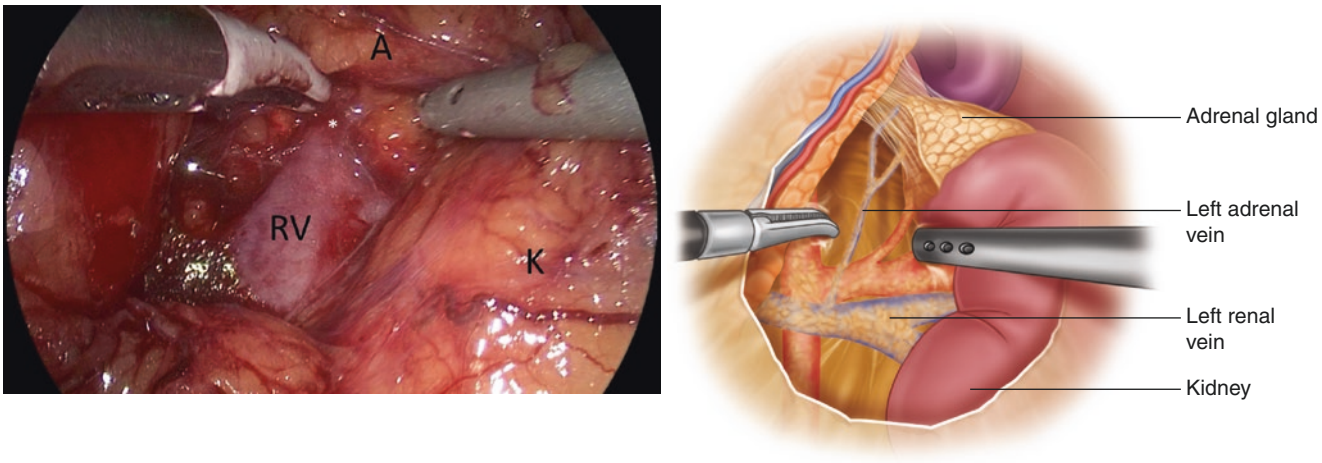


Fig. 4.10 An early view of the left renal vein and confluence of the left adrenal and left inferior phrenic veins can be seen here. The superior pole of the left kidney is seen on the right, the left adrenal gland and perinephric fat is at the top, and the tissue surrounding the tail of the pancreas and splenic vessels is to the left

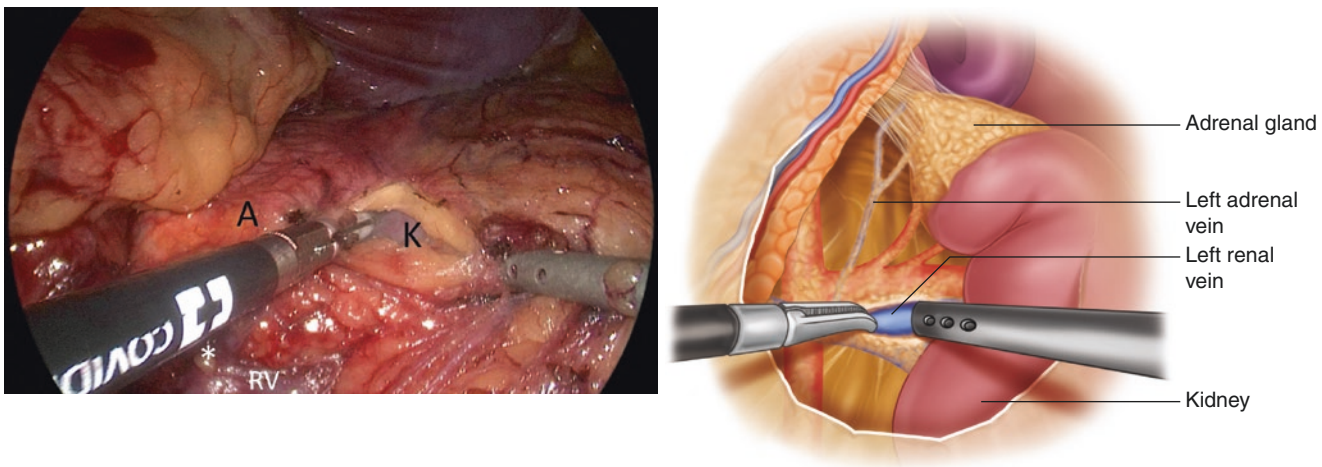


Fig. 4.11 Once the renal vein is identified, the tissue lateral to this between the inferior aspect of the adrenal gland and superior pole of the kidney can be divided. We routinely dissect this tissue down to the capsule of the kidney and then follow this kidney laterally taking all the periadrenal fat and tissue with the specimen. By keeping the dissection away from the adrenal capsule, we minimize the risk of adrenal capsular violation

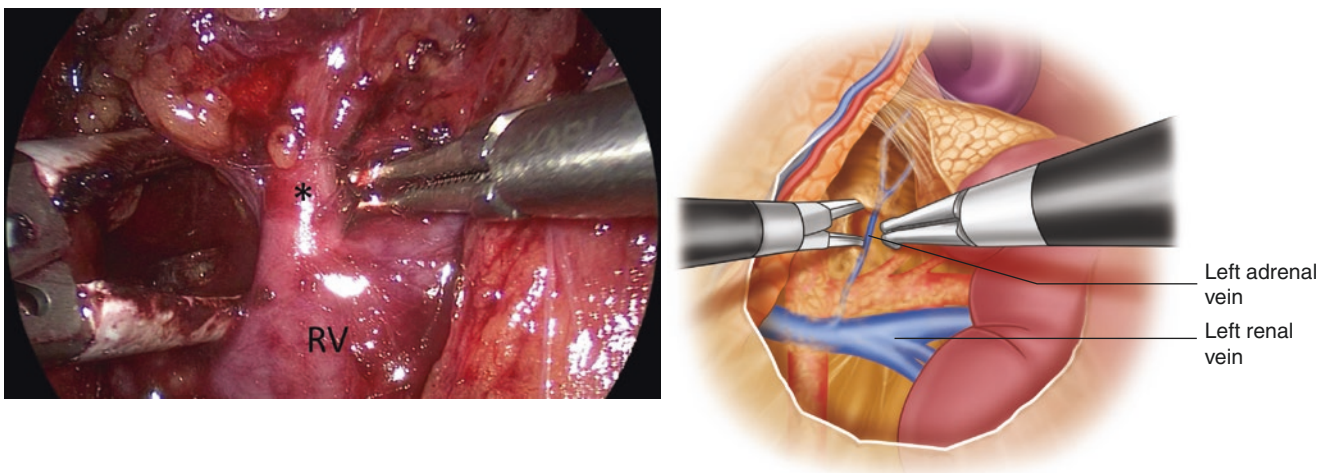


Fig. 4.12 Following careful circumferential dissection and isolation of the left adrenal vein, it can be more clearly visualized. This dissection allows for lengthening of the vessel for easier ligation and division a safe distance from the renal vein

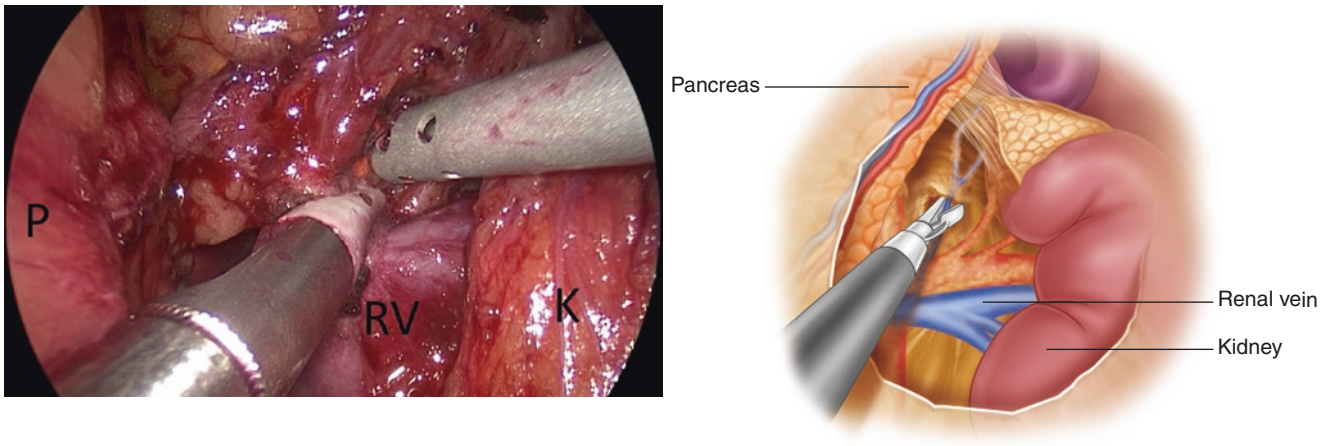


Fig. 4.13 The vein can be ligated and divided using a vessel-sealing energy device or incised between clips

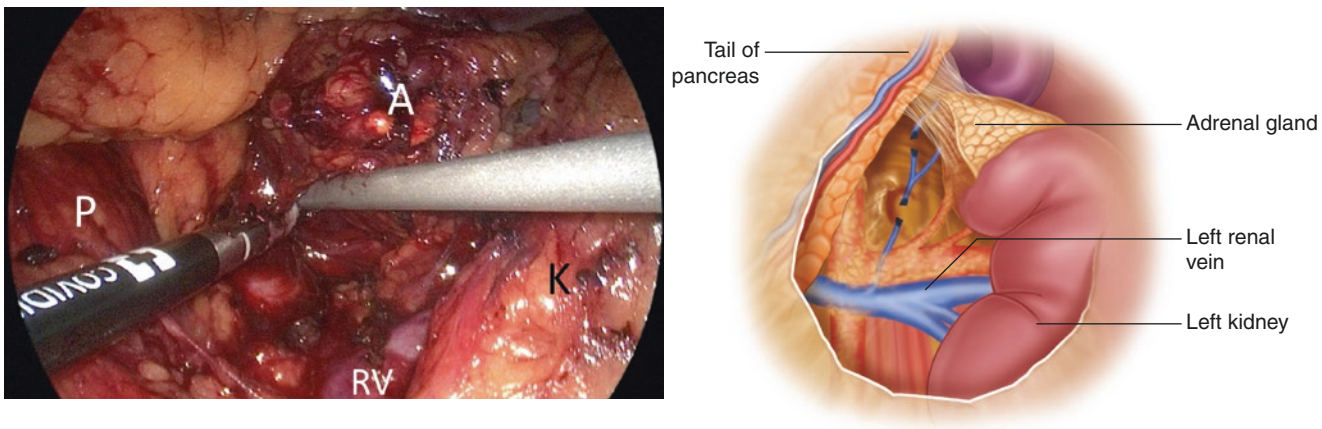


Fig. 4.14 After ligation and division of the adrenal vein, the adrenal gland and periadrenal tissue are elevated, and the plane of dissection that was begun along the superior pole of the kidney is extended medially, and then the dissection progressed in a cranial direction along the anterior aspect of the psoas muscle

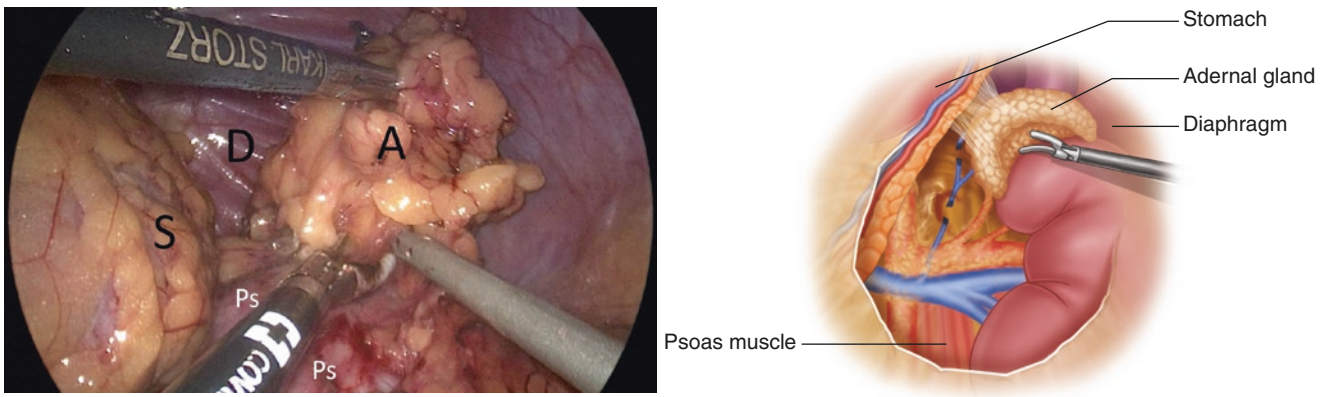


Fig. 4.15 The adrenal gland and periadrenal fat are then elevated and fully dissected from the underlying psoas muscle, superior pole of the kidney, and lateral retroperitoneal tissue up to the diaphragm. Care should be taken along the superior medial aspect of the dissection to avoid inadvertently injuring the fundus of the stomach

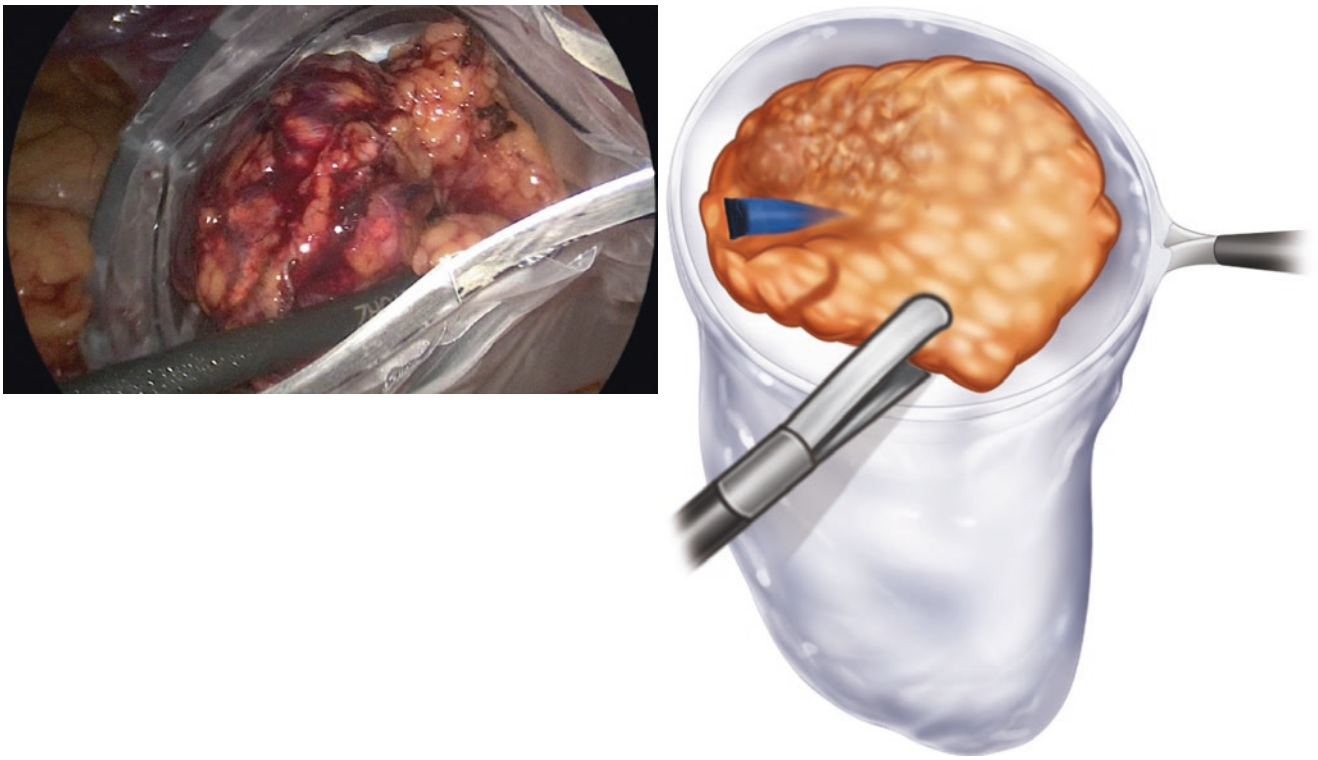


Fig. 4.16 An endoscopic specimen retrieval bag is then introduced through the posterior-most port, and the adrenal gland is removed. The gland can be morcellated inside the bag if malignancy is not suspected to allow for removal without extending the incision. However, we find that even large glands can be removed whole with only minimal extension of the incision and do not routinely morcellate the gland

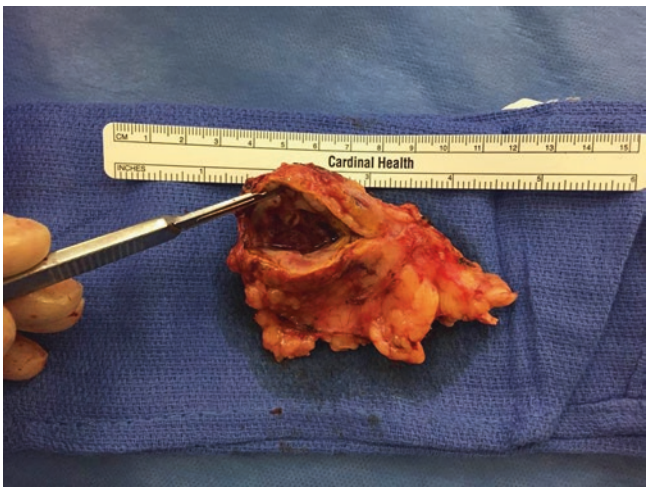


Fig. 4.17 Here, the pheochromocytoma can be seen having been incised. Inspection of the specimen showed no disruptions to the adrenal capsule

Suggested Reading

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Right Posterior Retroperitoneoscopic Adrenalectomy

5

Alexander Shifrin

The posterior retroperitoneoscopic adrenalectomy is a less invasive technique for the removal of the adrenal gland than the traditional laparoscopic transabdominal method. Known since the early 1990s, the technique was later introduced to the surgical community by Prof. Martin Walz from Essen, Germany. He perfected the technique and taught it to surgeons throughout the world, revolutionizing the surgical management of adrenal tumors. With posterior retroperitoneoscopic adrenalectomy, the adrenal glands are approached without entering the peritoneum, which avoids the following: (1) liver mobilization, dissection, and retraction on the right side and (2) colonic splenic flexure and spleen mobilization and retraction on the left side. Posterior retroperitoneoscopic approach is especially beneficial in patients with a history of prior abdominal surgeries (cholecystectomy, colon, or small bowel resection, etc.): the development of intraperitoneal adhesions will not influence the complexity of the posterior approach. The dissection is performed in the retroperitoneal space without entering the peritoneum. The posterior retroperitoneal approach however may not be familiar to some surgeons due to a different anatomical orientation. Advantages of this approach include shorter operative time, ability to perform bilateral adrenalectomy, ability to dissect the tumor located behind the vena cava, reduced postoperative pain for the patient, and quicker recovery. This approach has demonstrated excellent outcomes for nonfunctional and functional adrenal tumors, such as aldosteronoma (Conn's syndrome), Cushing's syndrome, and pheochromocytoma [1–6]. The usual cutoff size for the posterior approach is benign adrenal tumors smaller than 6 cm. For larger tumors or any suspicious of adrenocortical carcinoma, the anterior or open approach should be considered.

Key Points

1. Place all ports at the same distance from each other, usually 4 cm to allow for better mobility of laparoscopic instruments.
2. Place all ports under direct finger guidance. When cutdown is carried out for the middle port and retroperitoneal space is entered, insert a finger into the incision and swipe the pleura up (for the medial port placement) and peritoneum laterally (for the lateral port placement).
3. Maintain a higher insufflation pressure between 25 and 30 mm Hg to keep the retroperitoneal space open and to minimize bleeding from small vessels.
4. Always dissect the top of the kidney first and let the adrenal tumor with surrounding fat hang off—that is, be suspended. It will facilitate the dissection of the inferior aspect of the adrenal gland and the adrenal vein.
5. If there is bleeding from small vessels, the adrenal gland itself, or the vena cava uncontrolled by clipping or coagulating, insert a gauze into the retroperitoneal space. Use it to hold pressure over the bleeding area for several minutes. Most of the bleeding should cease.
6. Keep a small "pigtail" chest tube available in case the pleural space is incidentally compromised. This tube could be placed thoracoscopically (using the same camera directed into the pleural space) under direct visual guidance, inserted into the pleural space, and keeping it in place until the end of the case. The pigtail could be removed under negative suction pressure at the end of the procedure (assuming there is no lung injury).

Case Description

Patient is a 62-year-old woman with incidental findings of the right adrenal tumor on imaging studies in 2004 after a motor vehicle accident. She had no follow-up until 2016 when she

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_5) contains supplementary material, which is available to authorized users.

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had a kidney stone and a CT of the abdomen that revealed a 4.1 × 2.7 cm right adrenal mass with 20 Hounsfield units. MRI, both with and without contrast, demonstrated a 3.4 × 1.9 cm right adrenal tumor with loss of signal intensity on out-of-phase imaging consistent with adrenal adenoma. She was evaluated for functional adrenal tumor, and all her laboratory values were within normal ranges. Patient was diagnosed with a nonfunctioning right adrenal tumor and underwent a right posterior retroperitoneoscopic adrenalectomy. The final pathology was consistent with 4.0 cm adrenocortical neoplasm, favoring adenoma. Details of the case are seen in Figs. 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12, 5.13, 5.14, 5.15, 5.16, 5.17, and 5.18 and Video 5.1.

Procedure

The patient was securely positioned prone on the table with flexed hips and knees (Fig. 5.3).

Figure 5.4 shows landmarks for the trocars placement. The 12th rib was identified; the first trocar was then inserted at the tip of the 12th rib. The second trocar was placed about 4 cm medially to the first middle trocar at the edge of the longissimus dorsi muscle and 4 cm below the rib cage. The third trocar was placed at about 4 cm laterally to the first middle trocar. After the skin was cut for the first port placement, sharp scissors were used to enter retroperitoneum space at the level of the tip of the 12th rib. Using a finger, the

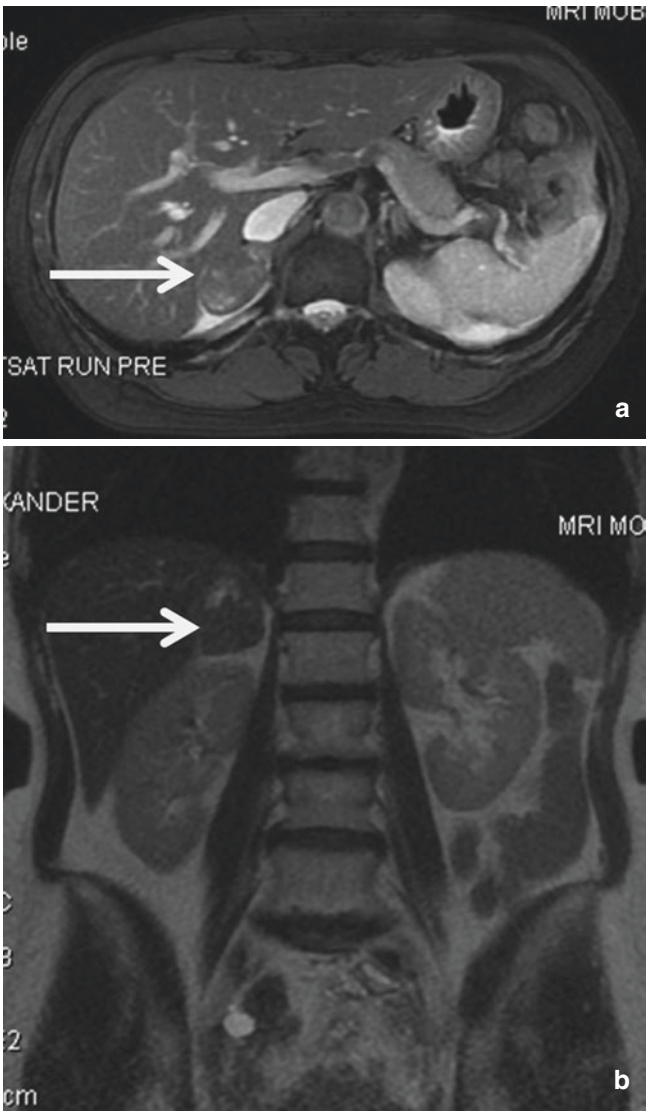

Fig. 5.1 Magnetic resonance imaging (MRI) scan, right adrenal tumor (a - transverse view, b - anterior veiw). There is a right adrenal lesion measuring 3.4 × 1.9 cm (arrow). It demonstrates significant loss of signal intensity on out-of-phase imaging. This is heterogeneously hyperintense on the T2-weighted images. It demonstrates low-signal intensity on the fat-suppressed gradient echo sequence and demonstrates heterogeneous enhancement following the administration of contrast

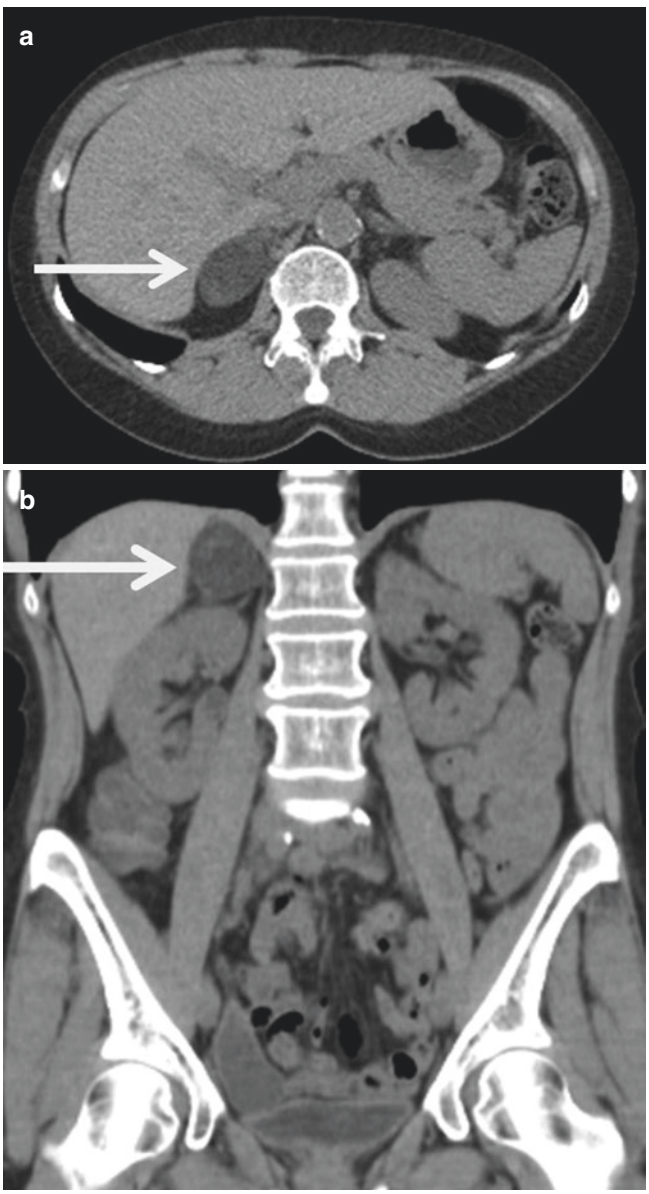

Fig. 5.2 Computed tomography (CT) scan, right adrenal tumor (a - transverse view, b - anterior virew). Right adrenal lesion measuring 4.1 × 2.7 cm with low-attenuation, 20 Hounsfield units (arrow)

Fig. 5.3 Patient's position. Patient is securely positioned prone on the table with flexed hips and knees

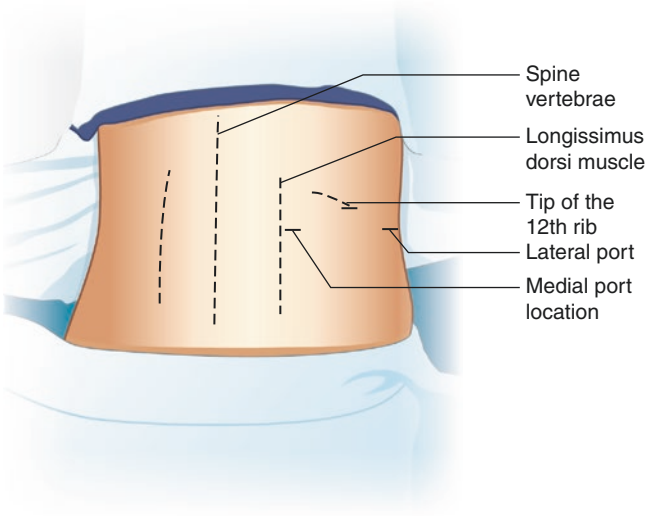

Fig. 5.4 Anatomical diagram for port placement. Diagram showing the anatomy for trocar placement: the first (middle) trocar was inserted at the tip of the 12th rib; the second trocar (medial port location) was placed about 4 cm medially to the first middle trocar at the edge of the longissimus dorsi muscle and 4 cm below the rib cage; the third trocar (lateral port location) was placed at about 4 cm laterally to the first middle trocar

working space was created bluntly underneath of the 12th rib dissecting medially, superiorly, and laterally. All trocars were placed under direct finger guidance to avoid incidental injury to the kidney or entering into the peritoneum (lateral trocar) or pleural space (medial trocar) (Fig. 5.5). The camera was inserted into the middle port where the Gerota's fascia was visualized (Fig. 5.6). The opening into the retroperitoneal space through the Gerota's fascia was created by using a LigaSure device. The insufflation pressure was elevated to 25–30 mm Hg. The retroperitoneal adipose tissue, overlying the right kidney, was visualized and dissected by pushing it down with the laparoscopic "peanut" dissector and going into the retroperitoneal space up to the level of diaphragm (Fig. 5.7).

After the creating of the retroperitoneal space above the kidney, using continued insufflation with 25–30 mm Hg, the camera was replaced from the middle port (the first trocar) to the medial port (the second, paraspinal trocar). The dissection was continued over the upper pole of the kidney, in between the kidney and the fatty tissue surrounding the adrenal gland inferiorly, by using a LigaSure device (Fig. 5.8.). Pushing the upper pole of the kidney down with the laparoscopic "peanut," the dissection was carried out from the lateral aspect of it medially toward the vena cava. Small arteries are seen coming off the aorta toward the adrenal gland and crossing posteriorly to the vena cava (toward the operator view) (Fig. 5.9). Vena cava is located immediately behind and underneath of the small arterial branches. Those branches were divided using a LigaSure device (Fig. 5.10.). With the tumor positioned posteriorly to the vena cava (in front of the vena cava from the posterior view), it may be difficult to visualize the adrenal vein right away. In this case some lateral and superior dissection will facilitate tumor mobility for lateral retraction and visualization of the vena cava at the adrenal vein junction site. Mobilization of the adipose tissue surrounding the adrenal gland from the lateral peritoneum overlying the liver (Fig. 5.11), and superiorly from the diaphragm (Fig. 5.12), is carried out using a LigaSure device. After that, the adrenal tumor can be easily retracted laterally with the peanut (Fig. 5.13). The vena cava with the right adrenal vein is visualized. The right angle was used to dissect the space superi-

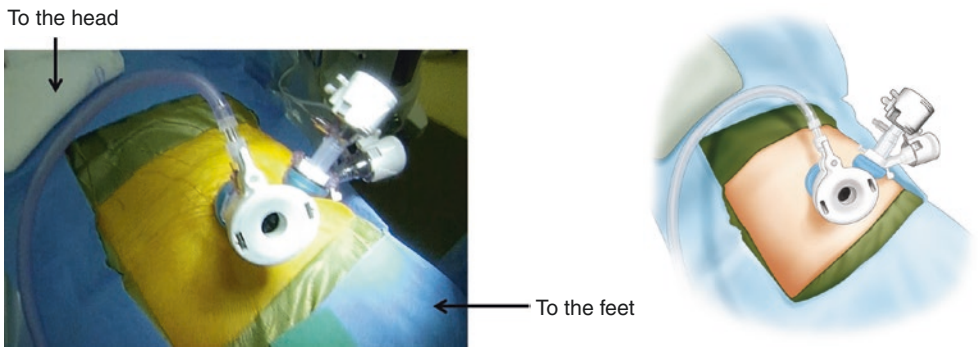

Fig. 5.5 Port placement. Three ports are placed into the right retroperitoneal space under direct finger guidance: First, middle port, at the level of the tip of the 12th rib; second, medial port, 4 cm medially to the middle port, at the edge of longissimus dorsi muscle, and 4 cm below the edge of the 12th rib; and third, lateral port, 4 cm laterally to the middle port

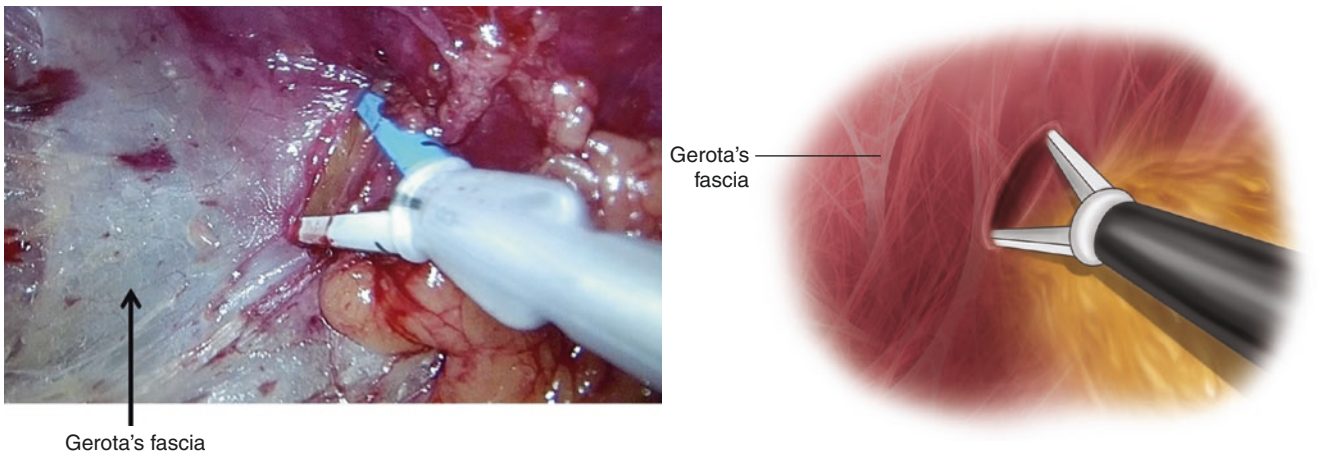

Fig. 5.6 Entering into the retroperitoneal space through Gerota's fascia. Camera is inserted through the middle port. The opening into the retroperitoneal space through the Gerota's fascia is created by using LigaSure device

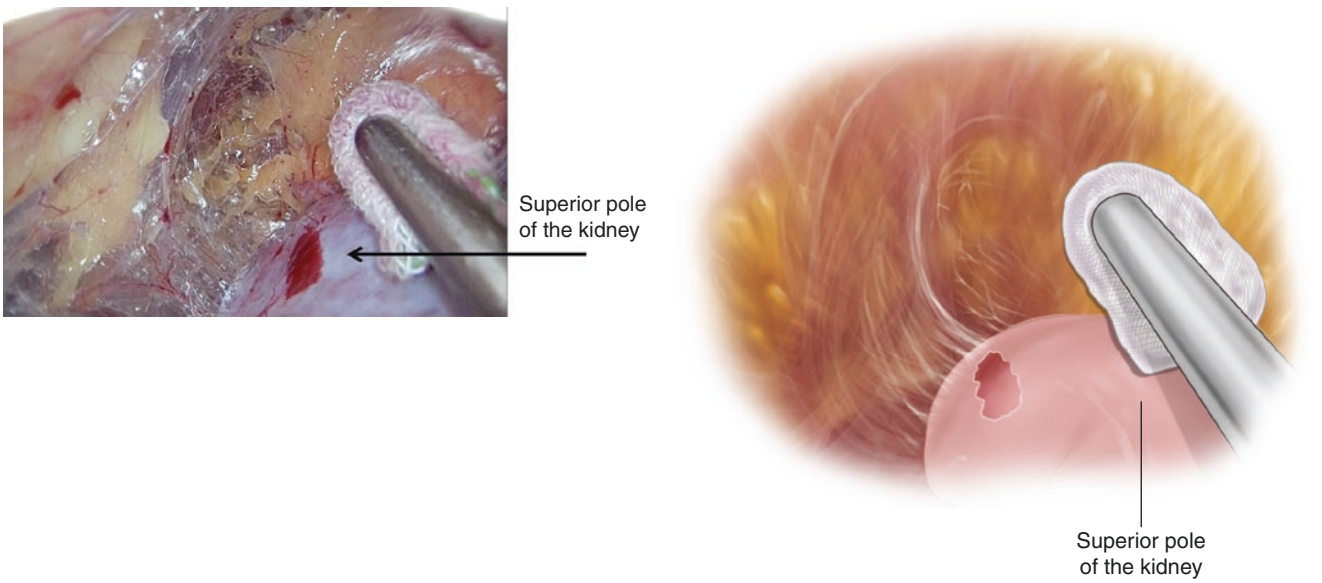

Fig. 5.7 The retroperitoneal space, dissection on the top of the right kidney. Upon entering the Gerota's fascia, the retroperitoneal space is insufflated at 25–30 mm Hg. Peanut is used to push the kidney down and dissect very superior aspect of the retroperitoneal space off the diaphragm

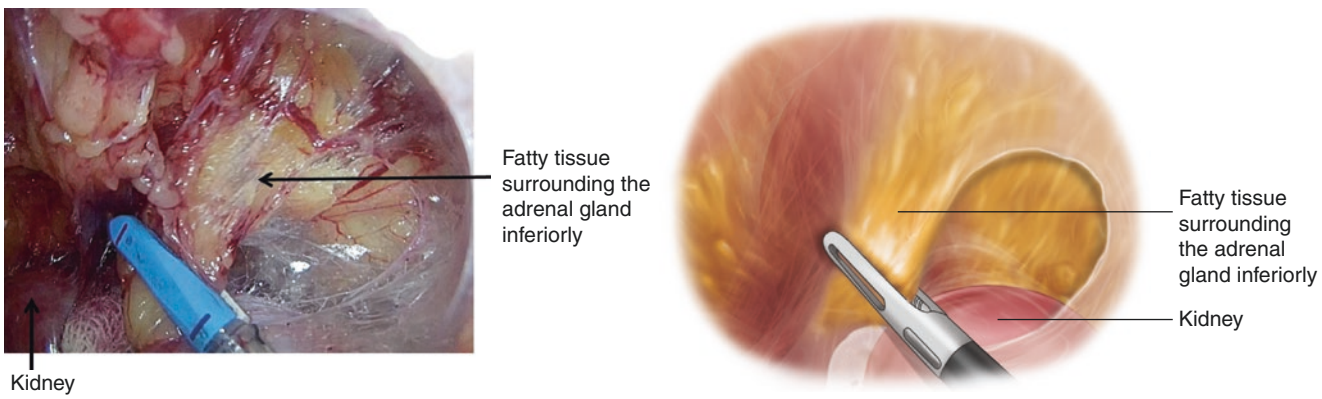

Fig. 5.8 The retroperitoneal space, dissection on the top of the right kidney. Camera then replaced from the middle port to the medial port. Dissection went up over the superior aspect of the kidney, between the kidney and the fatty tissue surrounding the adrenal gland inferiorly

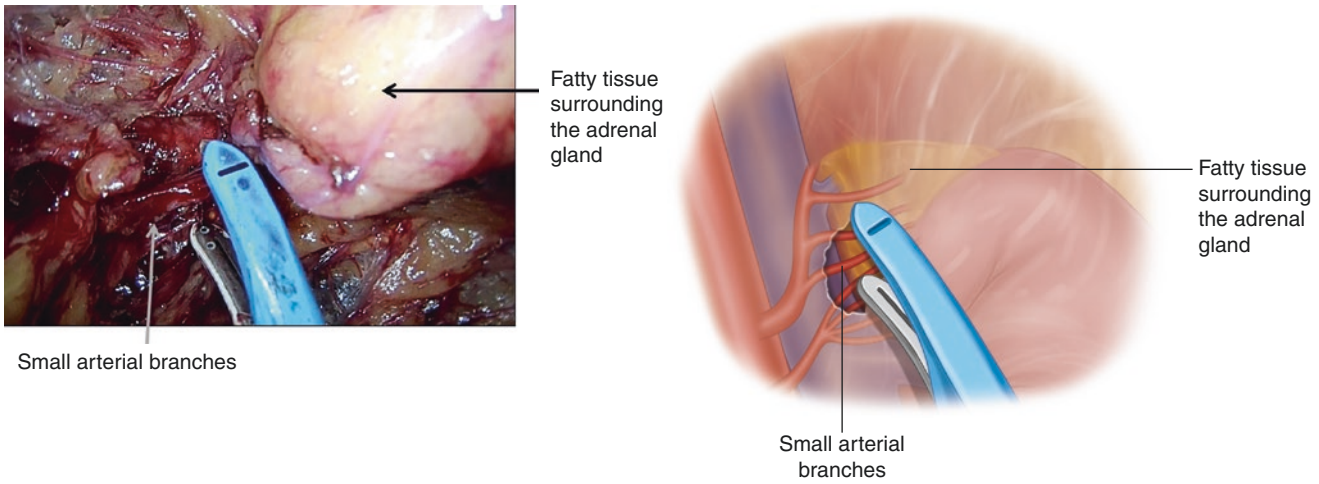

Fig. 5.9 The dissection on the top of the vena cava. The dissection went medially to the adrenal gland and over the vena cava. Using LigaSure device, all arterial branches coming off the aorta toward the adrenal gland are divided. Vena cava is located immediately underneath these branches. Fatty tissue surrounding the adrenal gland is superior and to the right

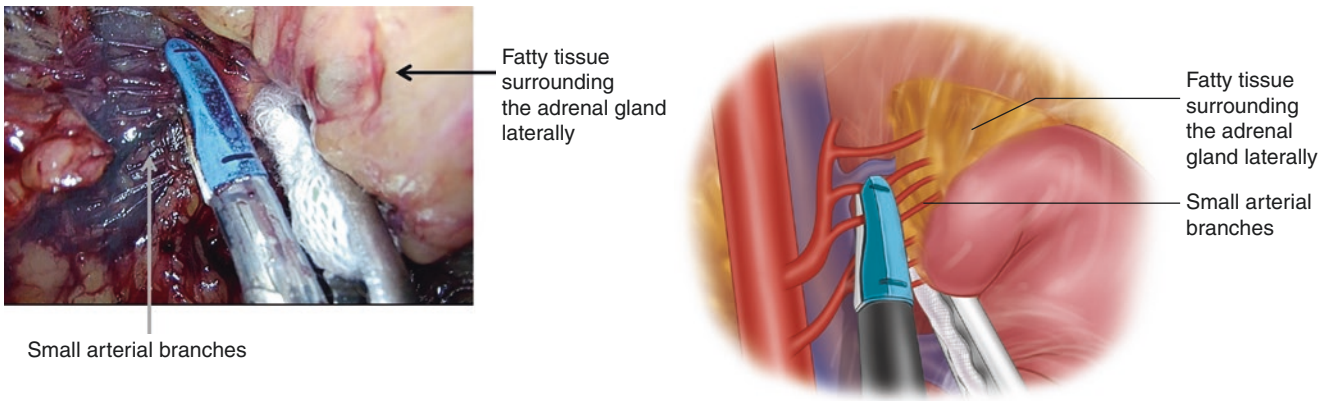

Fig. 5.10 Transection of the small vessels overlying vena cava and adrenal arteries. All small vessels and arterial branches coming off the aorta (*left*) toward the adrenal gland (*right*) are divided using LigaSure device. Vena cava is located immediately underneath these branches

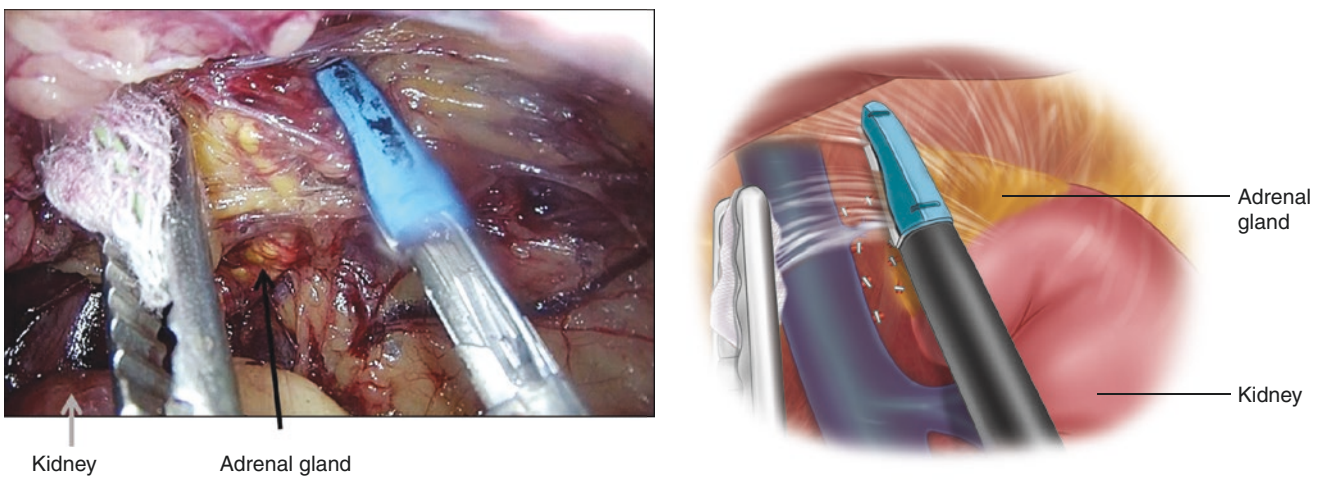

Fig. 5.11 Dissection of the lateral and superior attachment of the adrenal gland. Dissection went laterally in the retroperitoneal space between the liver (*right*) and the lateral aspect of the adrenal gland (*left*)

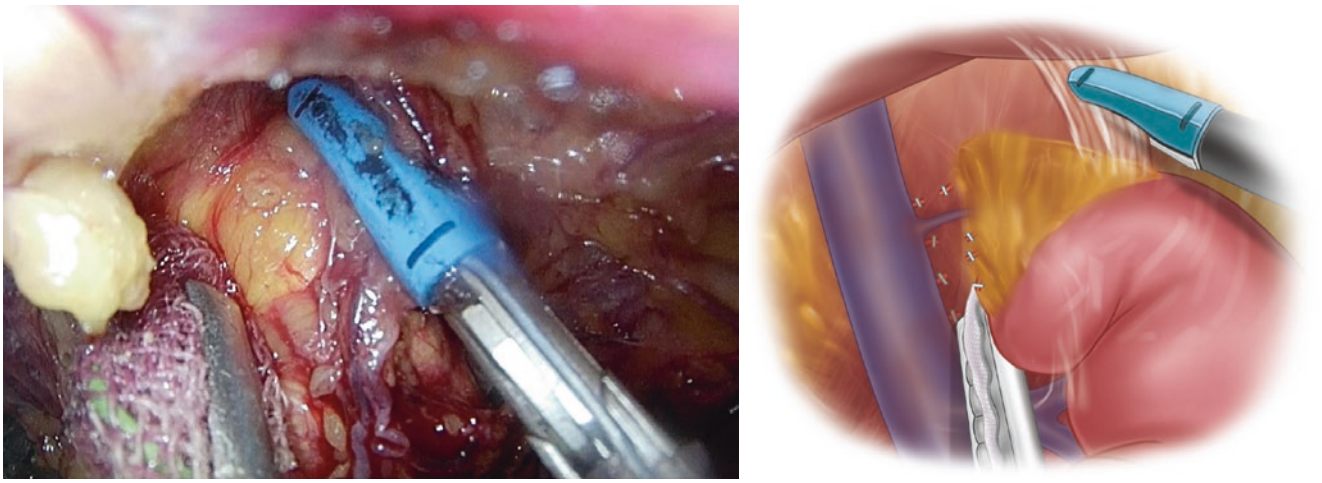

Fig. 5.12 Dissection of the anterior attachment of the adrenal gland. Dissection went anteriorly at retroperitoneal space, between the diaphragm anteriorly (*upper right corner*) and lateral aspect of the adrenal gland (*left lower corner*) which is retracted by the peanut

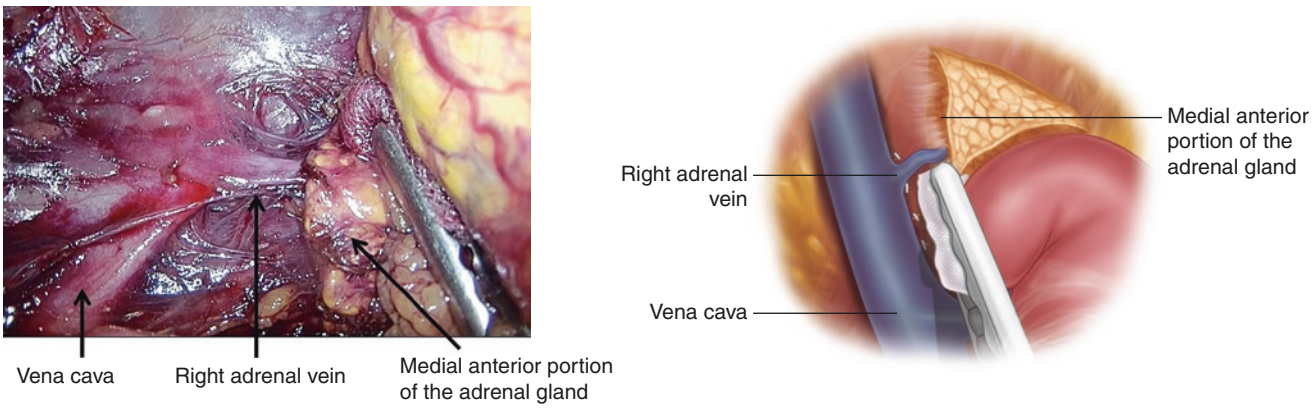

Fig. 5.13 Dissection of the adrenal vein. Adrenal gland is reflected laterally by the peanut (*right*) and underlying vena cave with the right adrenal vein is visualized

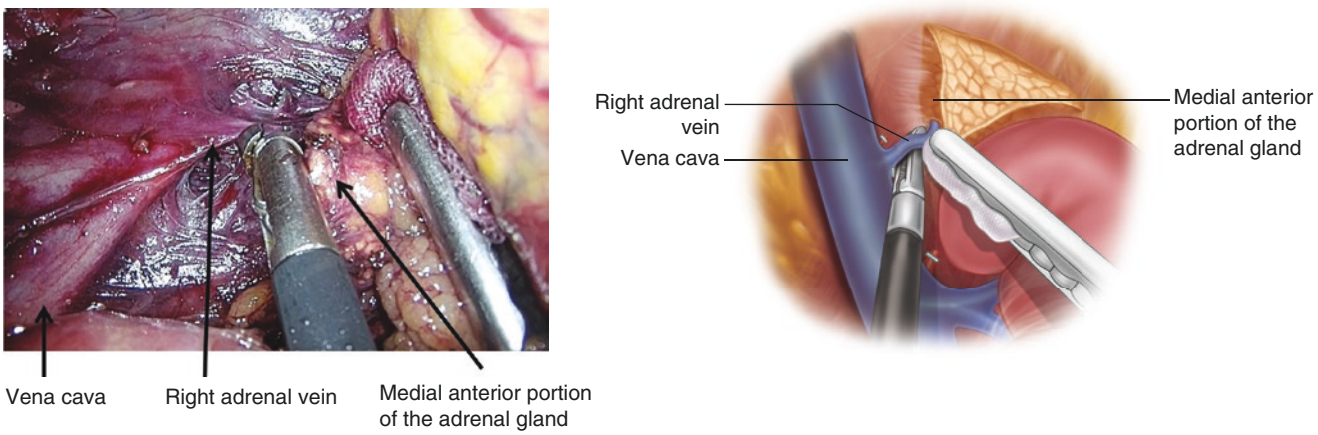

Fig. 5.14 Dissection of the adrenal vein. Adrenal gland is reflected laterally with the peanut (*right*). The right angle is used to dissect adrenal vein circumferentially

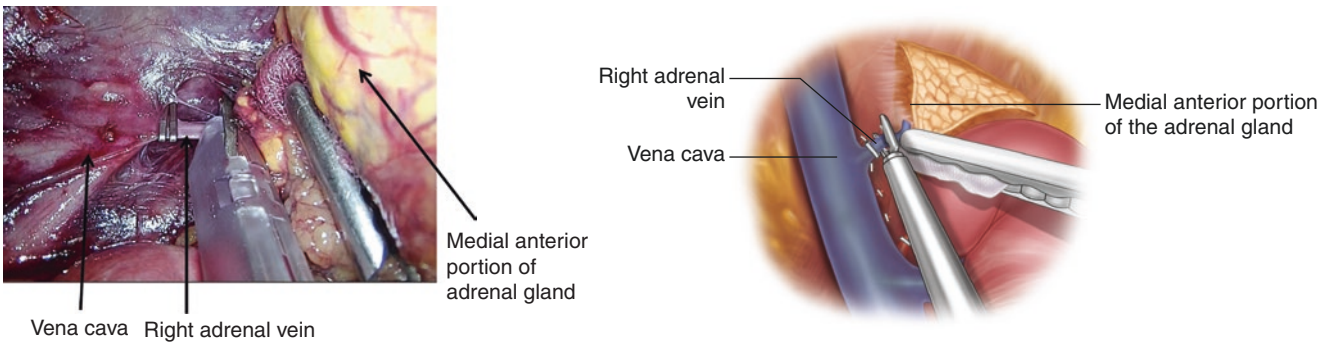

Fig. 5.15 Clipping of the adrenal vein. Adrenal gland is reflected laterally with the peanut (*right*). A 10-mm clip applier is used to clip the adrenal vein (two clips placed medially toward the vena cava and one laterally toward the adrenal gland)

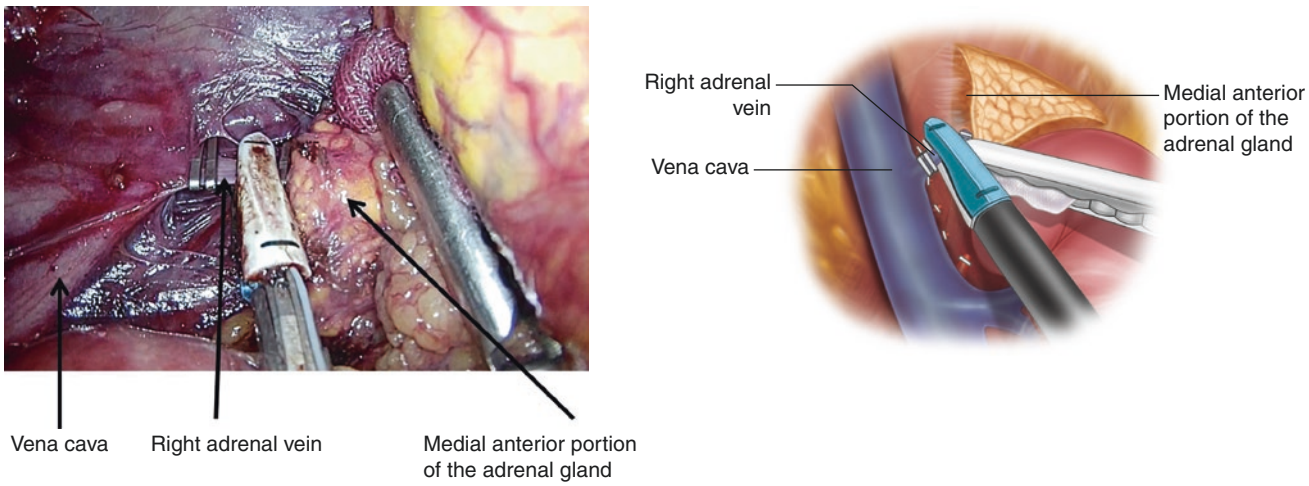

Fig. 5.16 Transection of the adrenal vein. The right adrenal gland is reflected laterally with the peanut (*right*). The LigaSure device is used to divide the adrenal vein in between the clips

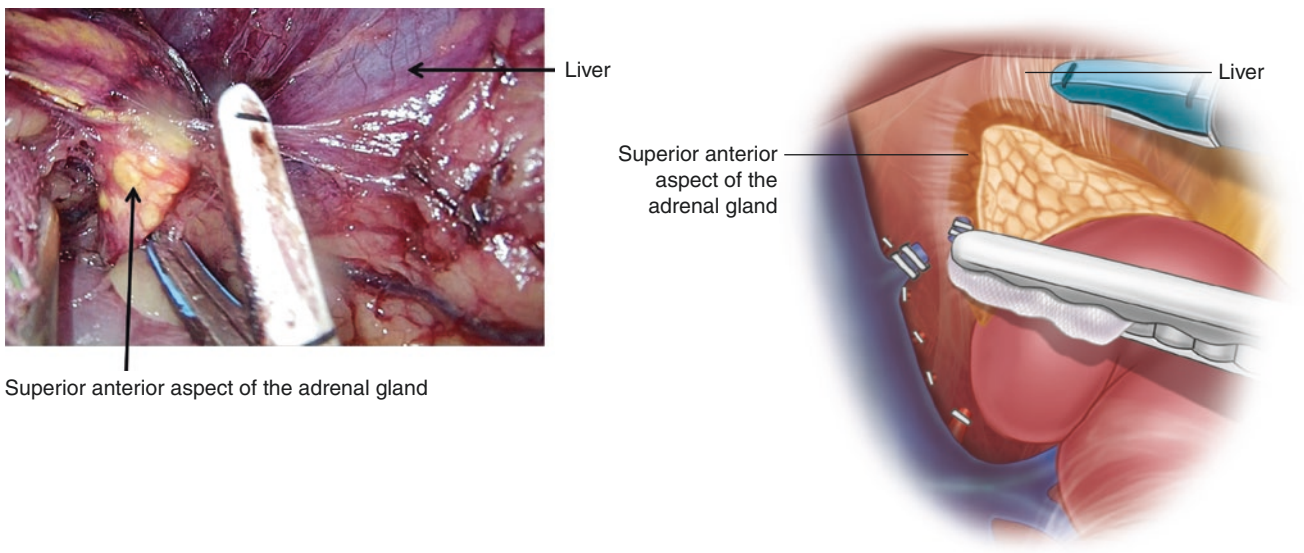

Fig. 5.17 Transection of the anterior peritoneal attachments. After the adrenal vein was divided, the adrenal gland is reflected medially and inferiorly; the remaining posterior attachments between the adrenal gland and posterior peritoneum (overlying the liver) are divided using the LigaSure device

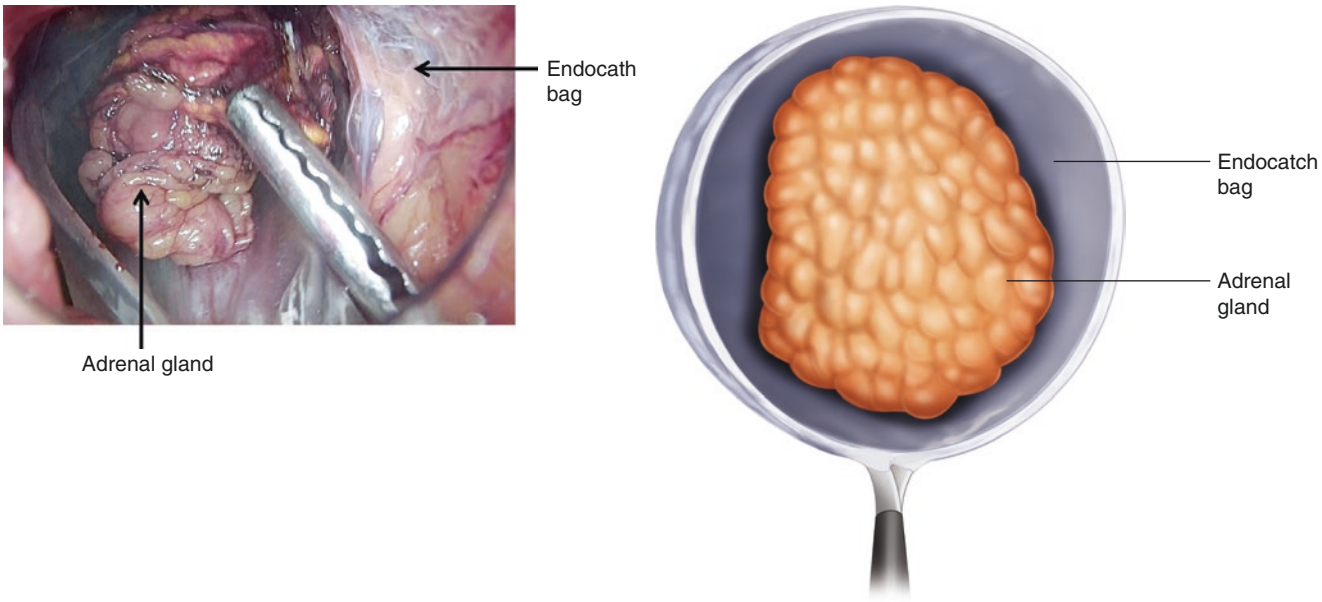

Fig. 5.18 Retrieval of the adrenal gland. The adrenal gland is placed into the endocatch bag and retrieved through the middle port

orly and then posteriorly to the adrenal vein to mobilize it circumferentially (Fig. 5.14). After space was created circumferentially, the adrenal vein was clipped. Using 10-mm clip applier, two clips were placed toward the vena cava and one toward the adrenal gland (Fig. 5.15.). In the above case, there was enough room to use a LigaSure device to transect the right adrenal vein in between the clips (Fig. 5.16.). After transection of the adrenal vein, the adrenal tumor was retracted laterally with the laparoscopic "peanut." The remaining medial attachments overlying the vena cava were divided by using the LigaSure device and then going superiorly toward the diaphragm. The adrenal gland was then retracted inferiorly and medially with the laparoscopic "peanut." The reaming anterior peritoneal attachments between the fatty tissue surrounding the adrenal gland and the peritoneum (anteriorly and laterally overlying the liver) was divided using a LigaSure device (Fig. 5.17). The adrenal gland was placed into the endocatch bag and retrieved through the middle port (Fig. 5.18). During the retrieval, the retroperitoneal space was deflated and later examined for possible bleeding vessels to be visualized and controlled during reinsufflation. The space was reinsufflated, and the cavity was vigorously irrigated with normal saline solution. Surgicel, an absorbable hemostatic agent, was placed into the adrenal bed. Drains were not used. All port sites were approximated and closed by layers. Dermabond was applied to the skin.

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Left Partial Posterior Retroperitoneoscopic Adrenalectomy

6

Alexander Shifrin

Introduction

The left posterior retroperitoneoscopic adrenalectomy is a less invasive technique for the removal of the adrenal gland as compared to the traditional left laparoscopic transabdominal method. This technique, known since the early 1990s, later was introduced to the surgical community by the world expert in this approach, Prof. Martin Walz from Essen, Germany. He has not only perfected this technique but also taught it to other surgeons throughout the world, revolutionizing the surgical management of adrenal tumors. The adrenal gland is approached without entering the peritoneum, which avoids colonic splenic flexure and spleen mobilization. Posterior retroperitoneoscopic approach is especially beneficial in patients with a history of prior abdominal surgeries. Intraperitoneal adhesions will not influence the complexity of the posterior approach. The dissection is performed in the retroperitoneal space without entering the peritoneum. The posterior retroperitoneal approach, however, may not be as familiar to some surgeons due to a different anatomical orientation. The posterior approach can be used to perform bilateral adrenalectomies as well. The advantages of this approach are shorter operative time, less postoperative pain, and quicker recovery. This approach has demonstrated excellent outcomes for nonfunctional and functional adrenal tumors, such as aldosteronoma (Conn's syndrome), Cushing's syndrome, and pheochromocytoma [1–8]. The posterior approach is recommended for benign adrenal tumors less than 6 cm. For bigger tumors, or any tumors suspicious for the adrenocortical carcinoma, the anterior or open approach should be considered.

Key Points

1. Place all ports at the same distance from each other, usually 4 cm; this allows better mobility of laparoscopic instruments.
2. Place all ports under direct finger guidance. When cutdown is carried out for the middle port and retroperitoneal space is entered, insert a finger into the incision and swipe the pleura up (for the medial port placement) and peritoneum laterally (for the lateral port placement).
3. Maintain a higher insufflation pressure, between 25 and 30 mm Hg, to keep the retroperitoneal space open and to minimize bleeding from small vessels.
4. Always dissect the top of the kidney first and let the adrenal tumor, with surrounding adipose tissue, hang off; in other words, allow it to be suspended. This will facilitate the dissection of the inferior aspect of the adrenal gland and the adrenal vein.
5. If there is bleeding from small vessels, or the adrenal gland itself, that is not controlled by clipping or coagulating, insert a gauze into the retroperitoneal space. Use it to hold the pressure over the bleeding area for several minutes. Most of the bleeding should cease.
6. Keep a small "pigtail" chest tube available in case the pleural space is incidentally compromised. This tube could be placed thoracoscopically (using the same camera directed into the pleural space) under direct visual guidance, inserted into the pleural space, and keeping it in place until the end of the case. The pigtail could be removed under negative suction pressure at the end of the procedure (assuming there is no lung injury).

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_6) contains supplementary material, which is available to authorized users.

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Fig. 6.1 MRI of the abdomen showing the left adrenal gland: there is a 1.0 × 0.6 cm lesion involving the medial limb of the left adrenal gland, which demonstrates loss of signal intensity seen on out-of-phase imaging consistent with an adenoma (arrow)

Procedure: Left Partial Posterior Retroperitoneoscopic Adrenalectomy

Case Presentation

A 61-year-old female presented with a history of an adrenal tumor for approximately 15 years (Video 6.1). She has recently developed hypertension and hypokalemia (potassium level 2.8 mmol/L [3.5–5.2 mmol/L]). A CT scan 2 years prior showed a 1.4 cm left adrenal tumor. Past surgical history was significant for several abdominal surgeries including a hysterectomy, a cholecystectomy, and an appendectomy. Evaluation revealed blood aldosterone level of 14 ng/dL (4–31 ng/dL), renin level of 0.4 pg/mL (2.5–45.7 pg/mL), and the aldosterone-renin ratio of 34 (normal less than 20). An MRI of the abdomen showed a left 1.0 × 0.6 cm adrenal tumor (Fig. 6.1). She had adrenal venous sampling performed, which demonstrated the presence of lateralization toward the left adrenal gland with lateralization index of 18 (diagnostic is above 4). The patient was diagnosed with primary hyperaldosteronism secondary to left adrenal adenoma. The patient was concerned about the removal of the entire adrenal gland and wanted to explore the option of a partial adrenalectomy. A mutual decision to remove only the part of the adrenal gland containing the adenoma was reached. She underwent a partial left posterior retroperitoneoscopic adrenalectomy. Her final pathology report was consistent with a 1.4 cm adrenal cortical adenoma. Her postoperative potassium, aldosterone, and renin levels returned to normal.

Description of Procedure

The patient was securely positioned prone on the operating table with flexed hips and knees (Fig. 6.2). Figure 6.3 depicts the anatomical diagram for trocar placement. The 12th rib was identified; the 1st (middle) trocar was then inserted at the tip of the 12th rib. The second (medial) trocar was placed about 4 cm medially to the first trocar at the edge of the longissimus dorsi muscle and 4 cm below the rib cage. The third (lateral) trocar was placed at about 4 cm laterally to the first (middle) trocar. After the skin was cut for the first port placement, sharp scissors were used to enter the retroperitoneal space at the tip of the 12th rib. Using a finger, the working space was created bluntly underneath the 12th rib, dissecting medially, superiorly, and laterally. All trocars were placed under direct finger guidance in order to avoid incidental injury to the kidney or entering into the peritoneum (lateral trocar) or pleural space (medial trocar). The camera was inserted into the middle port where the Gerota's fascia was visualized. The opening

Fig. 6.2 Patient's position. The patient was securely positioned prone on the table with flexed hips and knees

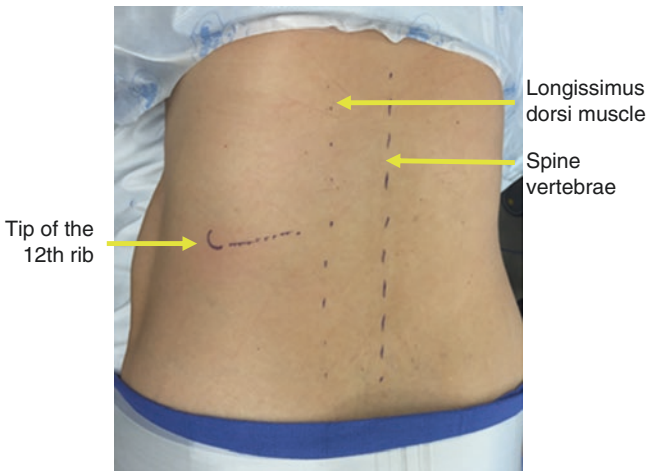

Fig. 6.3 Anatomical diagram for trocar placement. Three trocars are placed into the right retroperitoneal space under direct finger guidance: the first (middle) trocar is at the level of the tip of the 12th rib; the second (medial trocar), 4 cm medially to the middle trocar, at the edge of longissimus dorsi muscle and 4 cm below the edge of the 12th rib. The third (lateral trocar) is 4 cm lateral to the middle trocar. (a mirrow image of the Fig. 5.4)

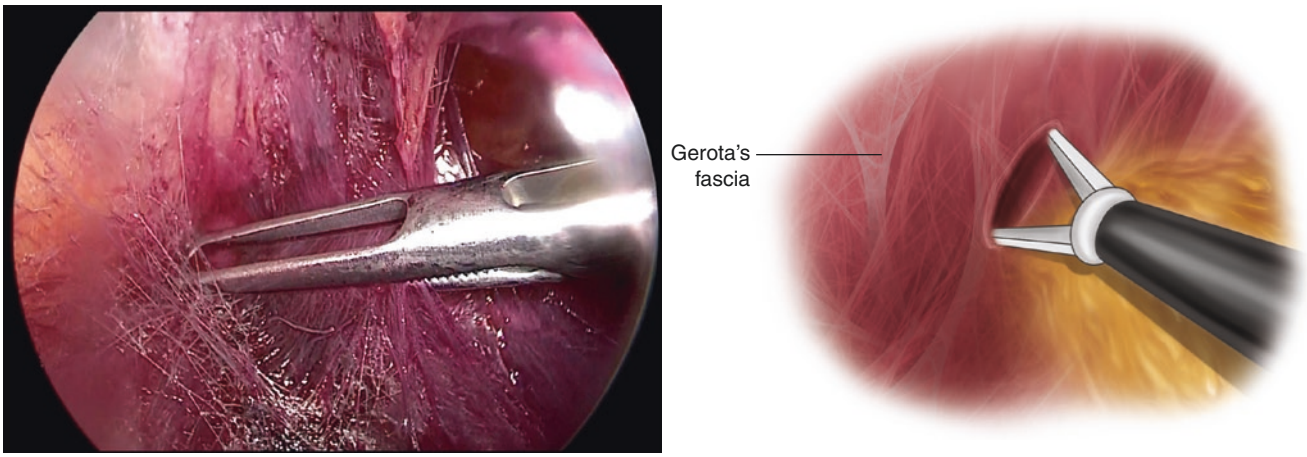

Fig. 6.4 Entering into the retroperitoneal space through Gerota's fascia. The camera is inserted through the middle port. The opening into the retroperitoneal space through Gerota's fascia is created by using a LigaSure device

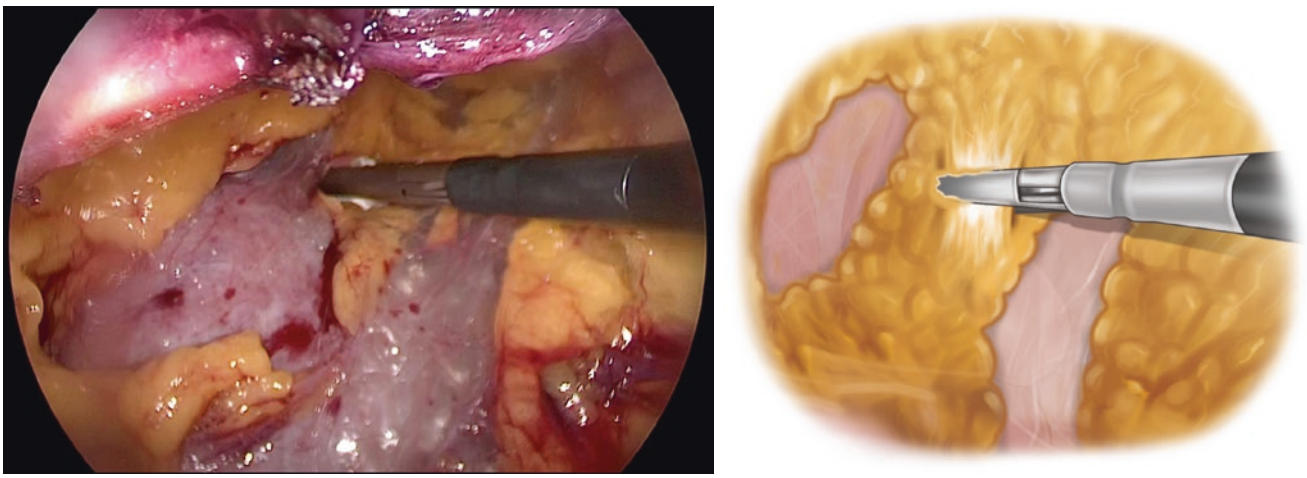

Fig. 6.5 The retroperitoneal adipose tissue, overlying the left kidney, was visualized and dissected by pushing it down with the laparoscopic peanut dissector and going into the retroperitoneal space up to the level of the diaphragm

into the retroperitoneal space through the Gerota's fascia was created by using a LigaSure device (Fig. 6.4). The insufflation pressure was elevated to 25–30 mm Hg. The retroperitoneal adipose tissue overlying the left kidney was visualized and dissected by pushing it down with the laparoscopic "peanut" dissector and going into the retroperitoneal space up to the level of diaphragm (Fig. 6.5). After the creation of the retroperitoneal space above the kidney, using continued insufflation with 25–30 mm Hg, the camera was replaced from the middle port (the first trocar) to the medial port (the second trocar). By using the LigaSure device, the dissection was continued over the upper pole of the kidney, in between the kidney and the adipose tissue surrounding the adrenal gland inferiorly (Fig. 6.6). Pushing the upper pole of the kidney downward with the laparoscopic "peanut," the dissection was carried out laterally from the medial aspect of the upper pole of the kidney (Fig. 6.7). The dissection was continued along the medial aspect to the adrenal gland (Fig. 6.8). Small arteries were visible branching off the aorta toward the adrenal gland were identified and dissected (Fig. 6.9). Then those branches were transected using a LigaSure device (Fig. 6.10.). The adrenal tumor was localized at the lateral superior part of the adrenal gland, and the margin in between the adrenal tumor and normal part of the adrenal gland was identified (Fig. 6.11). By using a LigaSure device, the adrenal gland was transected. The part of the adrenal gland with tumor is to the left, and the normal part of the adrenal gland is to the right as seen in Figs. 6.12, 6.13, and 6.14. The main adrenal vein originates at the inferior medial aspect of the adrenal gland and joins the renal vein at the level of the kidney. By leaving the inferior medial part of the adrenal gland intact, the functional aspect of the remaining adrenal tissue is preserved, and the normal venous outflow through the main adrenal vein is maintained. The posterior attachment between the peritoneum

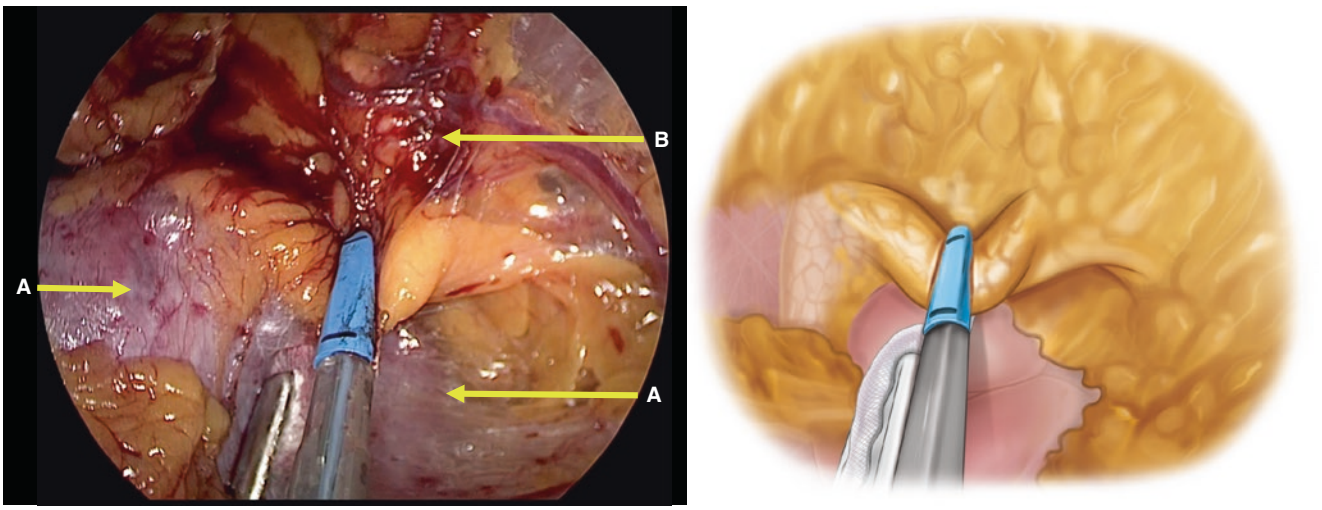

Fig. 6.6 The retroperitoneal space, dissection on the top of the left kidney. The camera is then replaced from the middle port to the medial port. Dissection went up over the superior aspect of the kidney, between the kidney (A) and the adipose tissue surrounding the adrenal gland inferiorly (B)

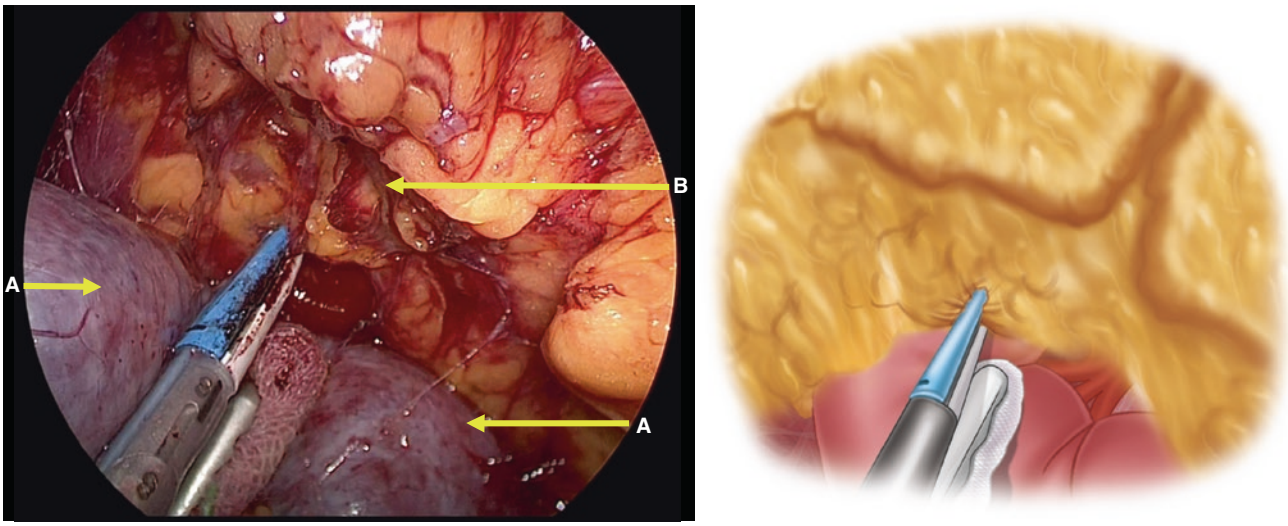

Fig. 6.7 Dissection between the superior aspect of the kidney (retracted with the laparoscopic peanut inferiorly and to the left) (A) and inferior aspect of the adrenal gland (superiorly and to the right) (B)

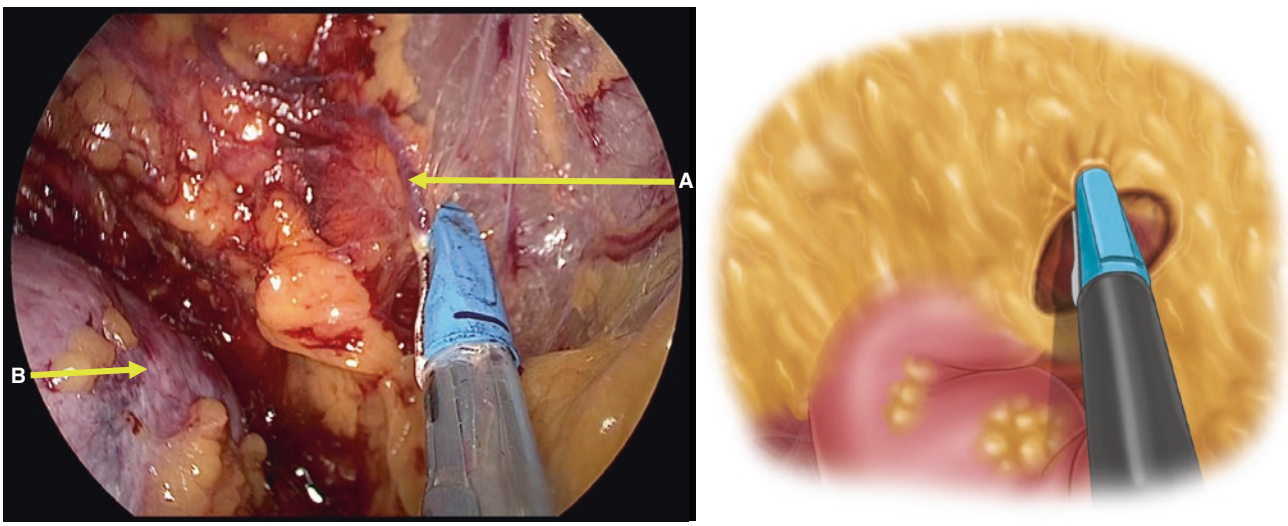

Fig. 6.8 Dissection is continued along the medial aspect to the adrenal gland (A) (the left kidney is to the left lower corner of the screen (B))

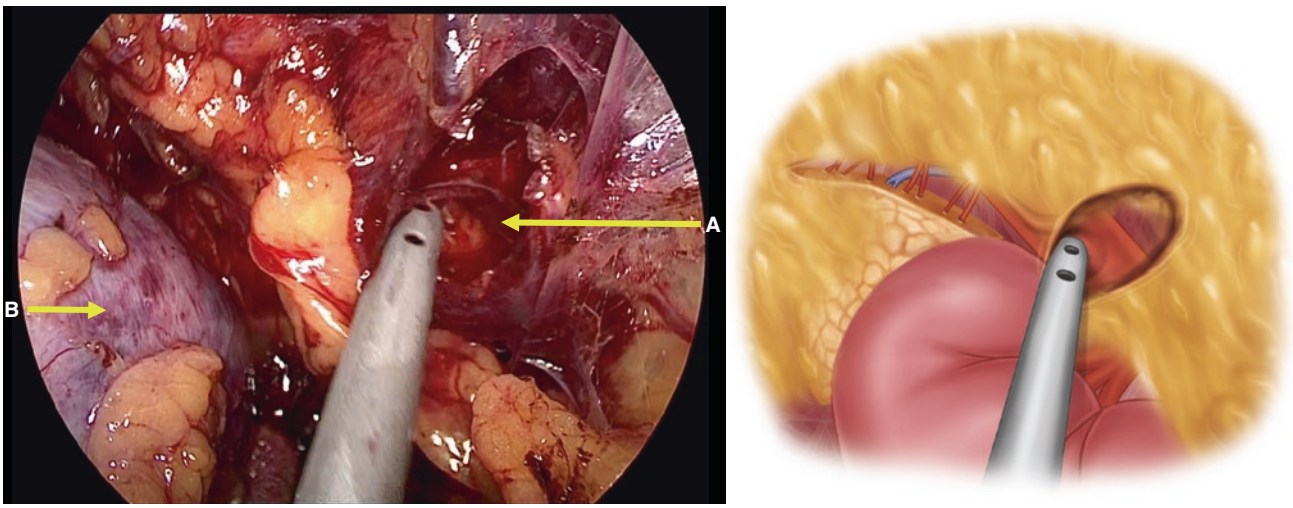

Fig. 6.9 Dissection is continued along the medial aspect to the adrenal gland (A) (the left kidney is to the left lower corner of the screen (B)), where small adrenal arteries are identified and dissected

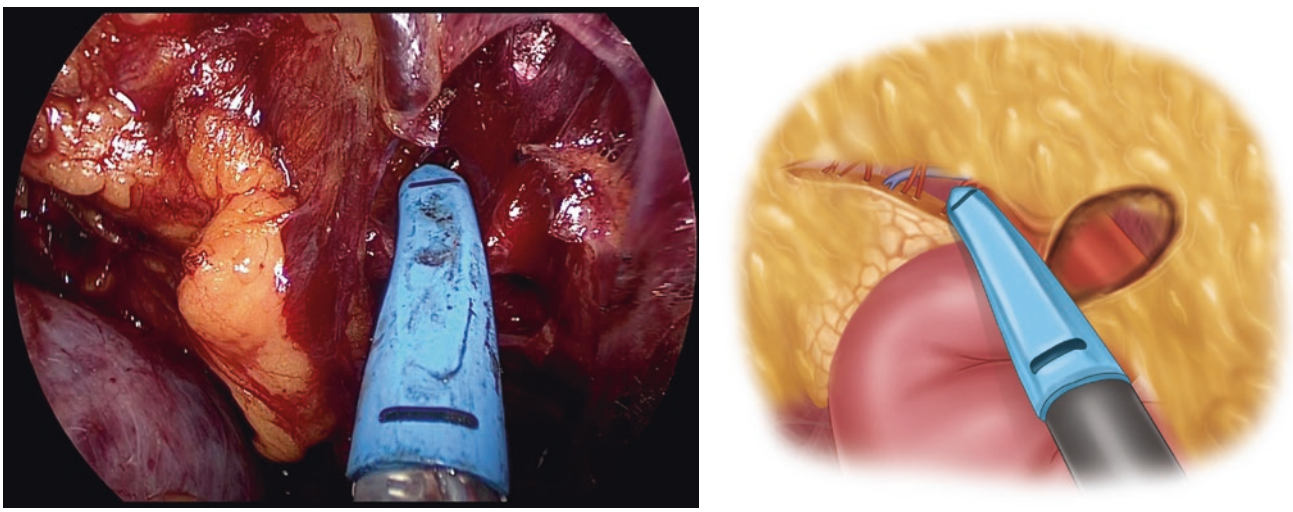

Fig. 6.10 Small adrenal arteries are transected using a LigaSure device

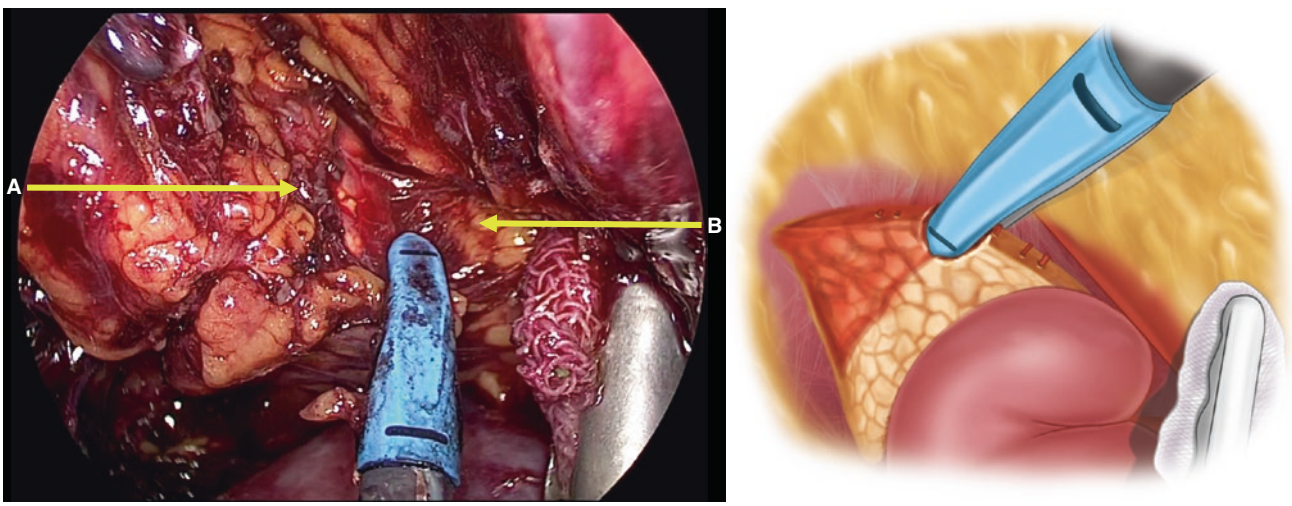

Fig. 6.11 Adrenal tumor is localized to the left of the screen (A), and the margin between the adrenal tumor and normal part of the adrenal gland is identified (B normal part of the adrenal gland). By using a LigaSure device, the adrenal gland is transected

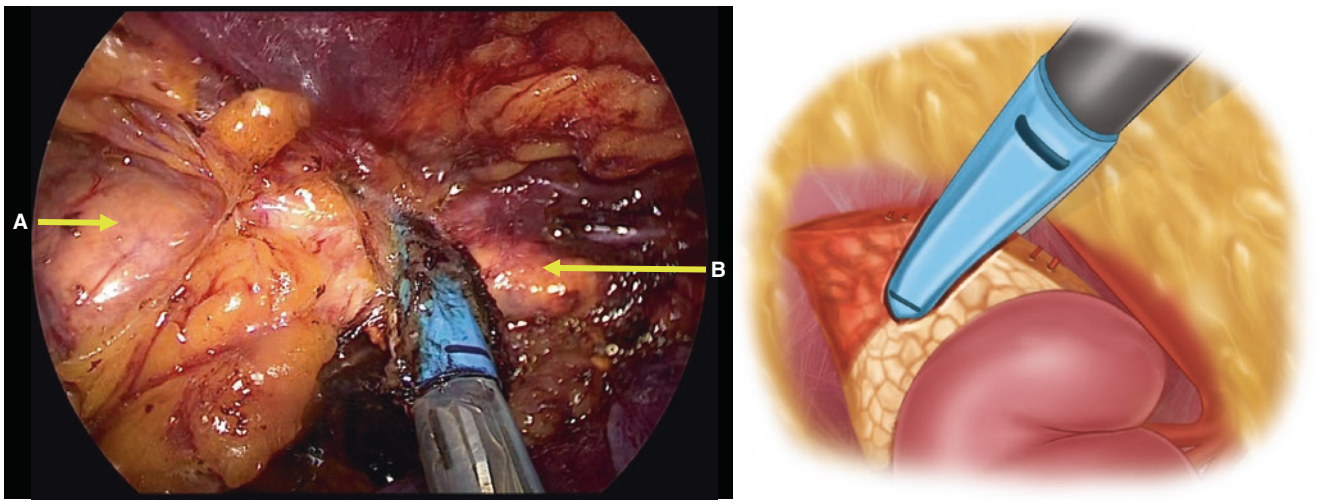

Fig. 6.12 Adrenal tumor is localized to the left of the screen (A). By using the LigaSure device, the adrenal gland is transected leaving the tumor to the left (A) and normal part of the adrenal gland (B) to the right of the screen. The adrenal vein is seen coming off the medial and inferior parts of the adrenal gland (the remaining part of the adrenal gland is to the right of the screen)

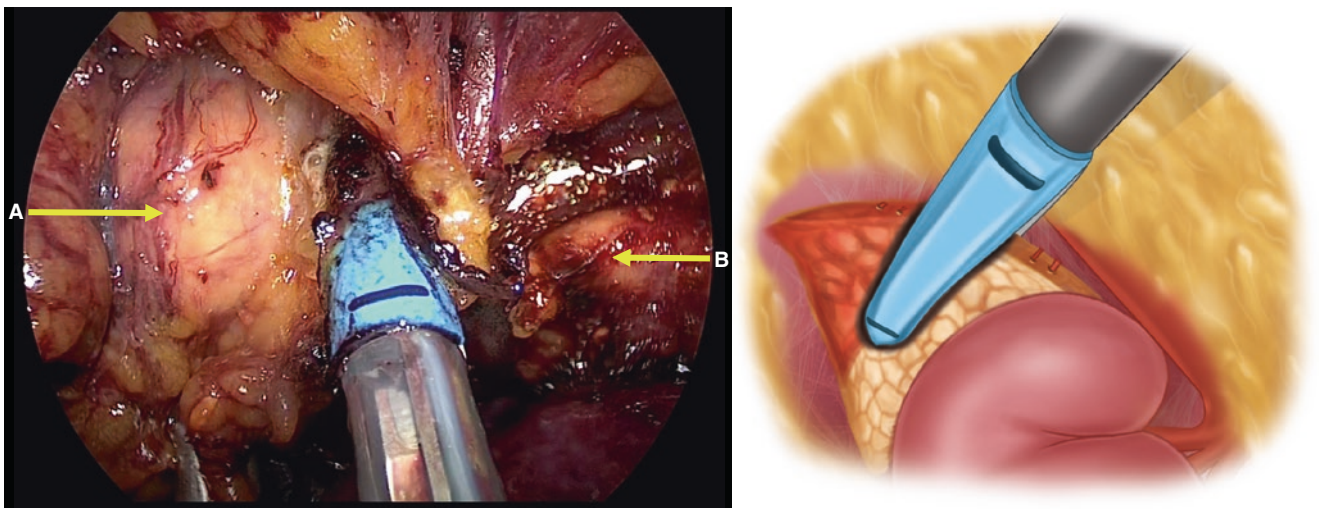

Fig. 6.13 Transection is carried out with the LigaSure device, leaving the tumor to the left (A) and normal part of the adrenal gland to the right of the screen (B)

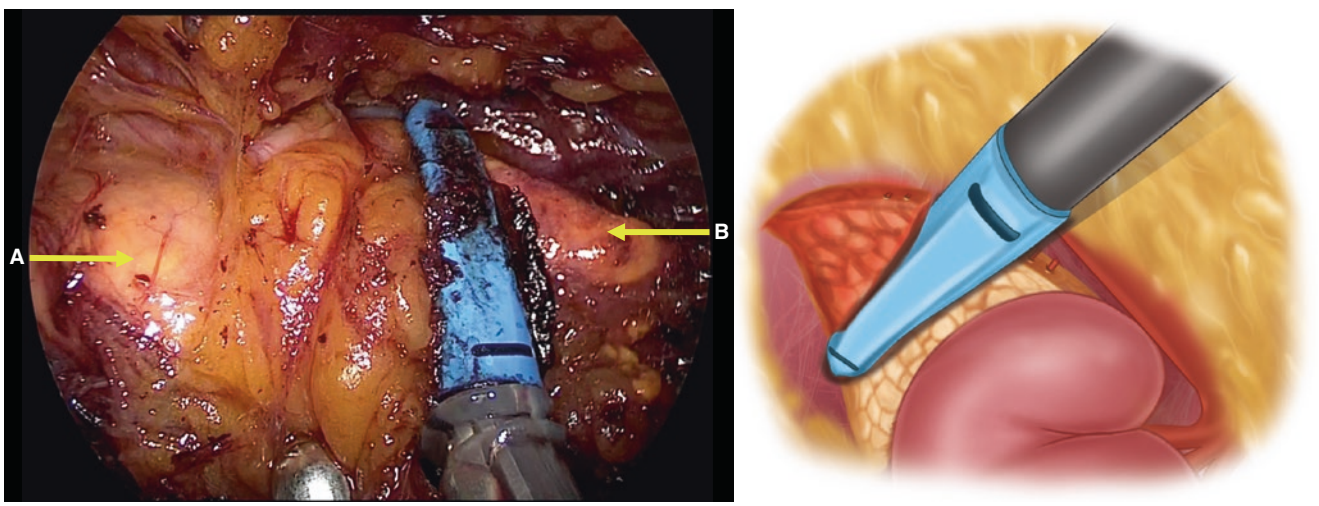

Fig. 6.14 Continued transection with the LigaSure device, leaving the tumor to the left (A) and the normal part of the adrenal gland to the right of the screen (B)

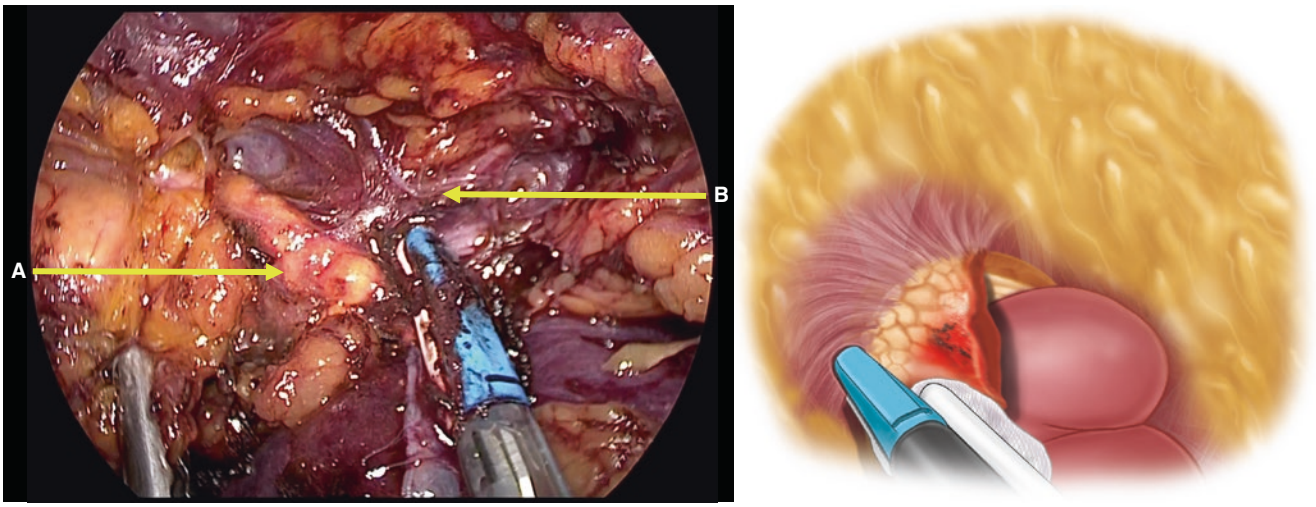

Fig. 6.15 Dissection of the posterior attachment of the distal part of the adrenal gland with tumor. Dissection went posteriorly at retroperitoneal space, between the peritoneum (to the upper right corner of the screen (B)) and lateral aspect of the adrenal gland with tumor (to the left lower corner of the screen (A)), which is retracted by the grasper

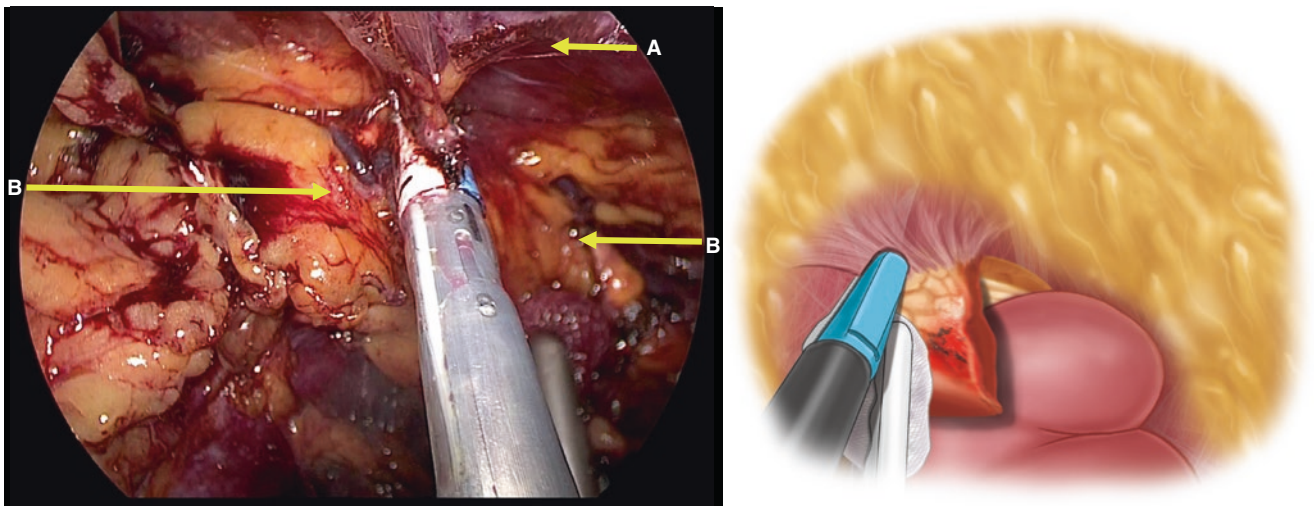

Fig. 6.16 Dissection of superior attachments of the distal part of the adrenal gland containing the tumor. Dissection carried out anteriorly at the retroperitoneal space, between the diaphragm anteriorly (to the upper right corner of the screen (A)) and lateral aspect of the adrenal gland containing the tumor (to the lower part of the screen (B)) retracted by the laparoscopic peanut

and lateral aspect of the adrenal gland was transected while keeping the tumor retracted by the grasper (Fig. 6.15). The dissection proceeded anteriorly at the retroperitoneal space, between the diaphragm anteriorly (to the upper right corner of the screen) and lateral aspect of the adrenal gland (to the left lower corner of the screen); the adrenal gland was retracted with the laparoscopic grasper (Fig. 6.16). The adrenal gland with the tumor was placed into the Endo Catch bag and retrieved through the middle port (Fig. 6.17). During the retrieval, the retroperitoneal space was deinsufflated and later examined for possible bleeding vessels. The space was reinsufflated and the cavity was vigorously irrigated with normal saline solution (Fig. 6.18). At the point of reinsufflation, any remaining bleeding vessels could be visualized and controlled. Surgicel, an absorbable hemostatic agent, was placed into the adrenal bed (Fig. 6.19). Drains were not used. All ports were approximated and closed by layers. Dermabond was used as the dressing for the skin (Fig. 6.20). Gross images of the portion of the adrenal gland with tumor are seen in Fig. 6.21.

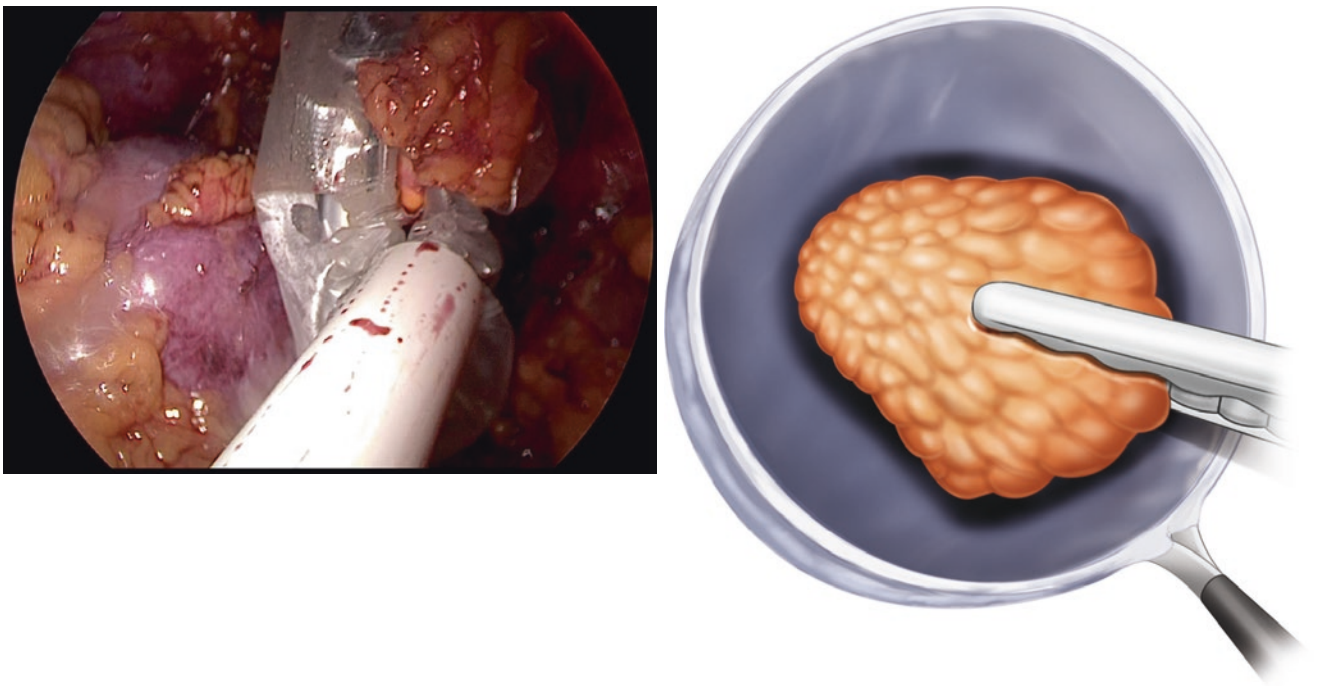

Fig. 6.17 Laparoscopic Endo Catch bag inserted into the middle trocar; the portion of the adrenal gland that contains the tumor is placed into the bag and retrieved

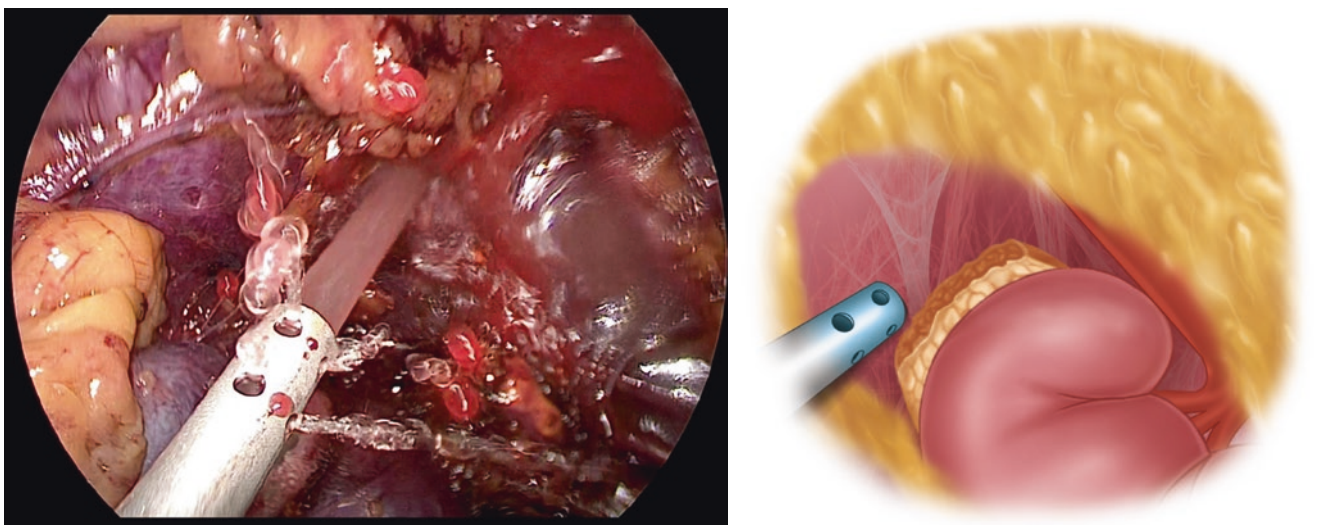

Fig. 6.18 Cavity is irrigated and hemostasis is confirmed

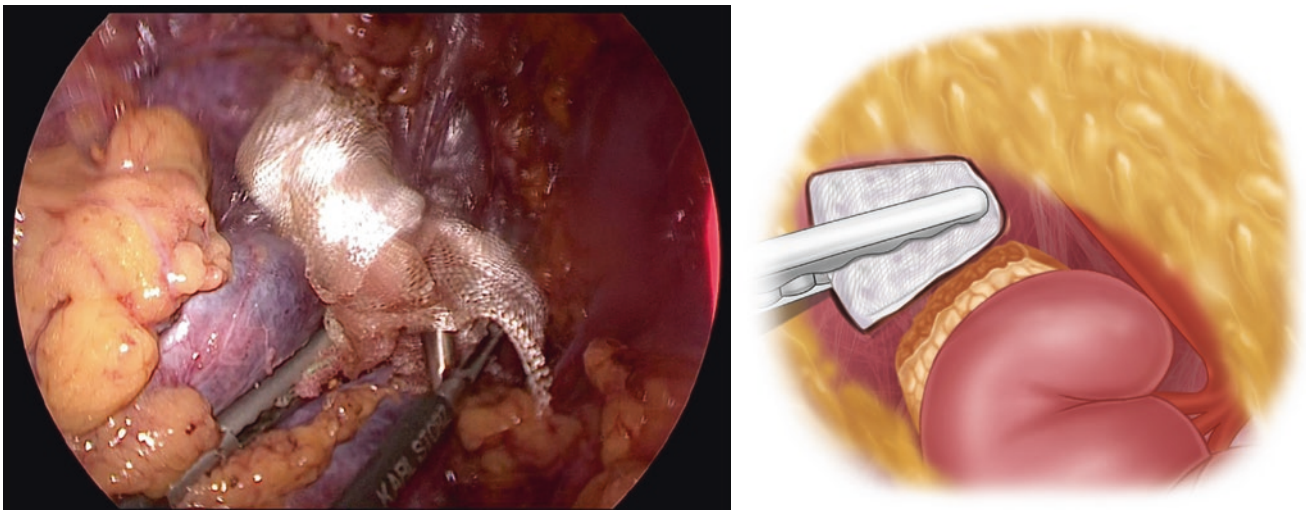

Fig. 6.19 Surgicel, an absorbable hemostatic agent, is placed into the adrenal bed

Fig. 6.20 All trocar ports are removed, incisions are closed by layers, and Dermabond is applied to the skin

Fig. 6.21 Gross image showing the portion of the adrenal gland containing the tumor

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Posterior Retroperitoneoscopic Right Cortical-Sparing Adrenalectomy

7

Michael E. Egger and Nancy D. Perrier

The posterior retroperitoneoscopic adrenalectomy is a minimally invasive approach to resect nonmalignant lesions of the adrenal gland. The benefits of the approach include minimal postoperative recovery, the ability to perform a bilateral resection without repositioning, and the avoidance of adhesions from prior abdominal surgery. We describe a cortical-sparing approach that is useful to treat pheochromocytoma in the setting of hereditary syndromes. With this approach, unaffected adrenal cortex is spared in an attempt to avoid future reliance on steroid supplementation in the event of a pheochromocytoma recurrence. Keys to the success of this operation include an understanding of the anatomic position of the pheochromocytoma based on preoperative imaging, identification of the appropriate anatomic landmarks intraoperatively, and the preservation of blood supply to the remnant adrenal gland.

Description: Retroperitoneoscopic Right Cortical-Sparing Adrenalectomy

The left or right adrenal can be removed by the posterior retroperitoneoscopic approach (Video 7.1). It is an appropriate technique for removing small (<6 cm) benign functioning or nonfunctioning adrenal tumors. The only absolute contraindication to the use of the approach is in the case of known or suspected primary malignancy. The benefits of the approach include the ability to approach bilateral tumors without repositioning, the avoidance of adhesions from previous surgery, and a well-tolerated postoperative recovery [1, 2].

The patient is positioned in the prone jackknife position after induction of general anesthesia. A Cloward surgical saddle is used to facilitate positioning (Surgical Equipment International, Honolulu, Hawaii) (Fig. 7.1). This positioning, on an appropriately sized Cloward saddle, causes the intra-abdominal contents to hang toward the floor, allowing gravity to pull the peritoneal contents away from the retroperitoneum. This point is critical, as it provides adequate exposure of the retroperitoneum once insufflation is achieved. To facilitate proper positioning, the patient's knees should be drawn up as close as possible to 90 degrees. The patient is secured to the bed with soft straps, and pressure points are padded.

Proper port placement is critical to a successful operation. The landmarks used for proper port positioning include the midline, the paraspinal muscles, and the tips of the 11th and 12th ribs (Fig. 7.2). The first port (12–15 mm) is placed just inferior to the tip of the 12th rib. After the retroperitoneum is entered with the tip of long, blunt scissors, a surgeon's finger is placed through the incision and develops the working space bluntly. The operator's finger in this space is then used to guide the placement of the medial port (10 mm) just lateral to the paraspinal muscles and the lateral port (5 mm), at the tip of the eleventh rib. We favor the use of an additional 5-mm port inferior and equidistant between the medial and middle ports (Fig. 7.3). A 15-mm balloon port is then placed in the initial port site, and insufflation is achieved with 20–24 mm Hg pressure.

The operating space is bluntly created with the help of the insufflation (Fig. 7.4). For a right adrenalectomy, the paraspinal muscles are identified as the medial (left screen side) extent of the dissection. The kidney is identified, and dissection is carried out from this point cephalad to identify the adrenal gland (Fig. 7.5). The inferior vena cava (IVC) is identified medially (screen left) to the adrenal and forms the floor of the dissection space (Fig. 7.6). This is one of the more dangerous parts of the procedure, prior to full exposure of the IVC, when the IVC is at risk of injury. The inferior and

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_7) contains supplementary material, which is available to authorized users.

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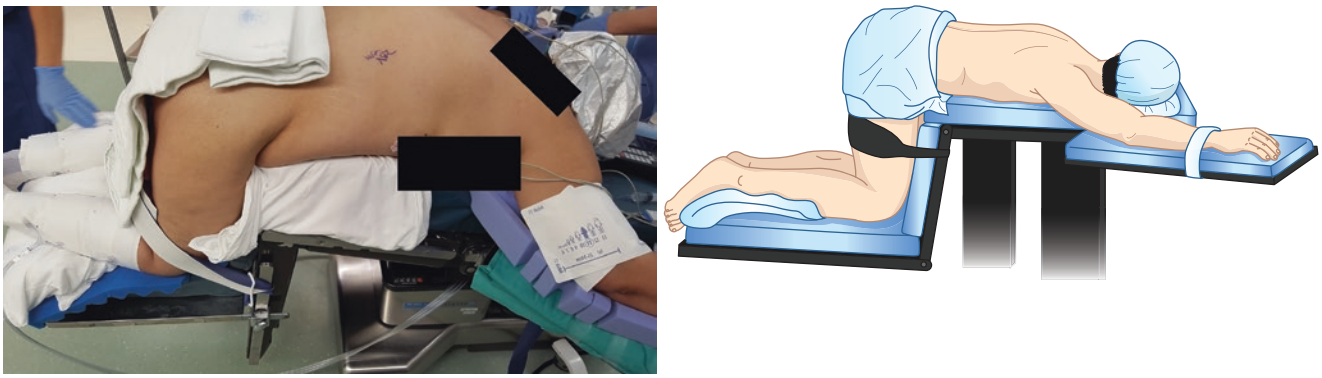

Fig. 7.1 Patient positioning in the prone jackknife position on the Cloward mattress

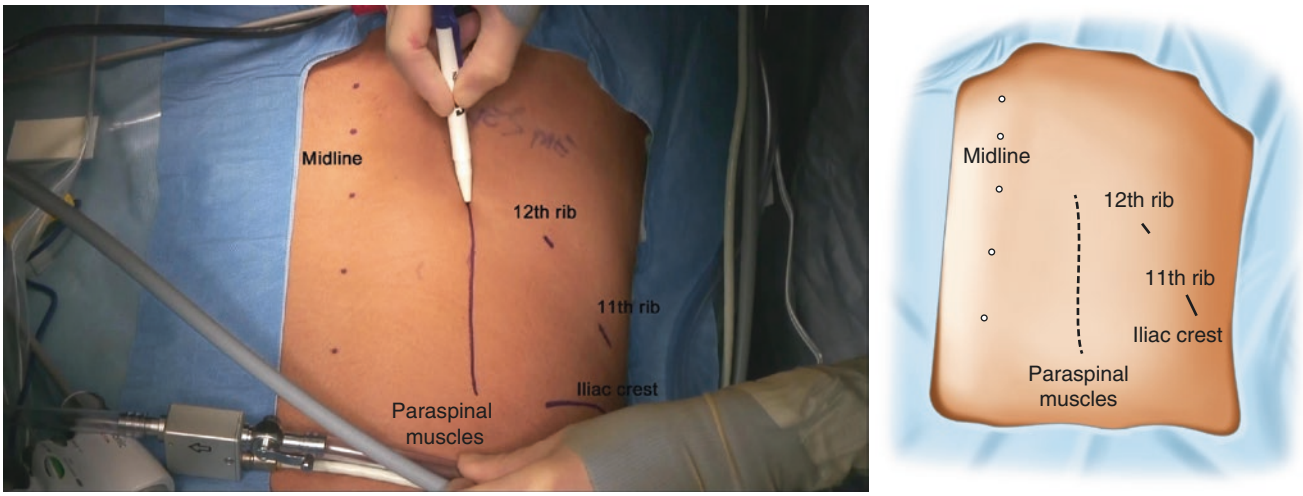

Fig. 7.2 The landmarks are identified and marked prior to port placement

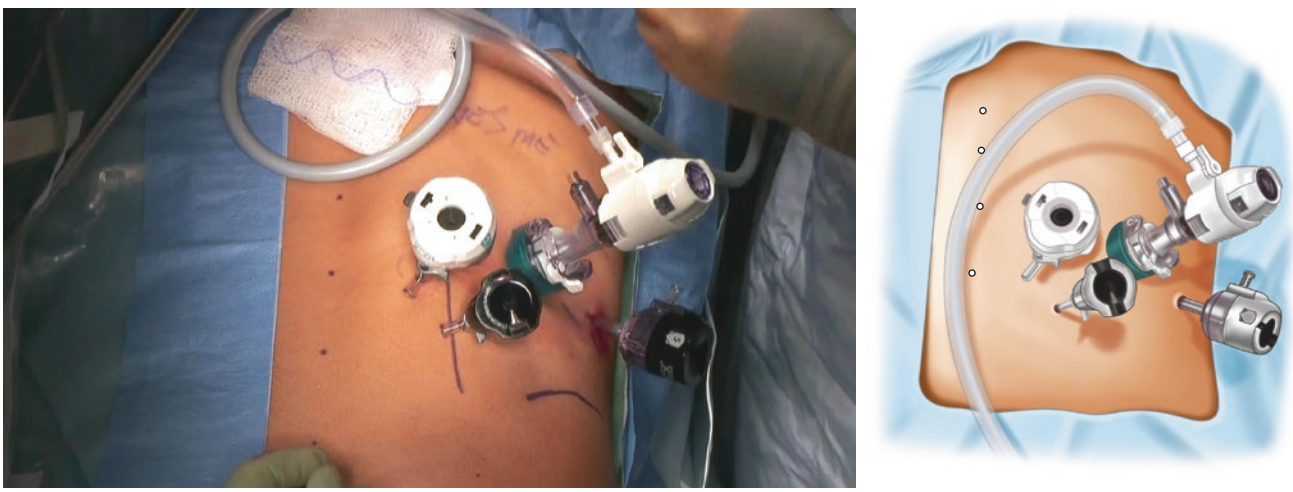

Fig. 7.3 Port placement for a right posterior retroperitoneoscopic adrenalectomy

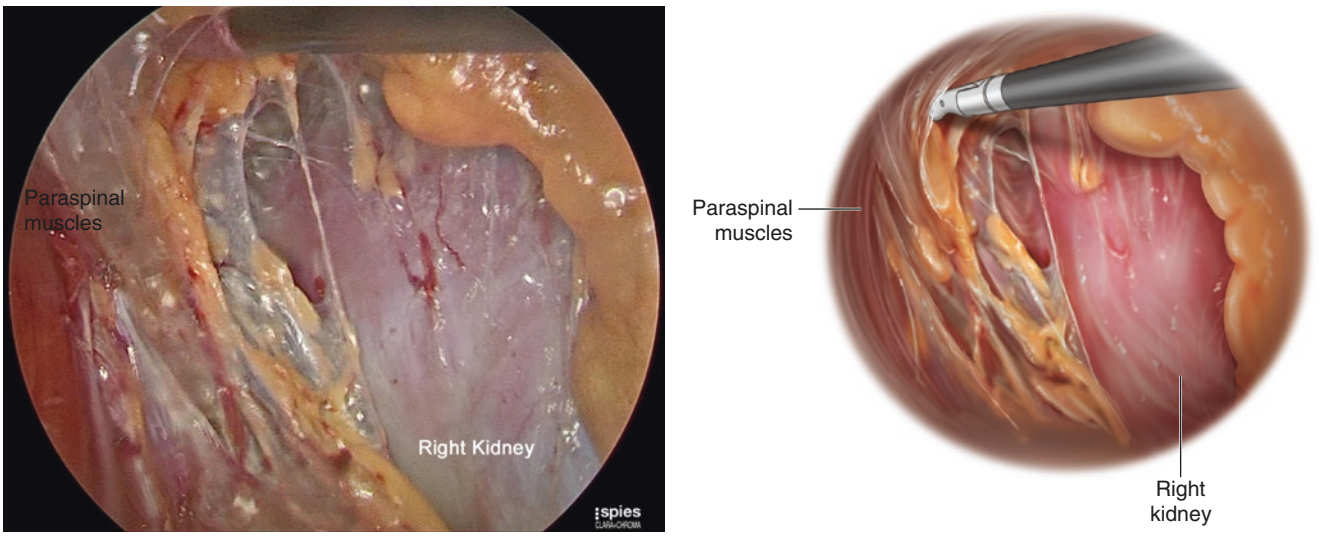

Fig. 7.4 The operating space in the retroperitoneum is developed bluntly

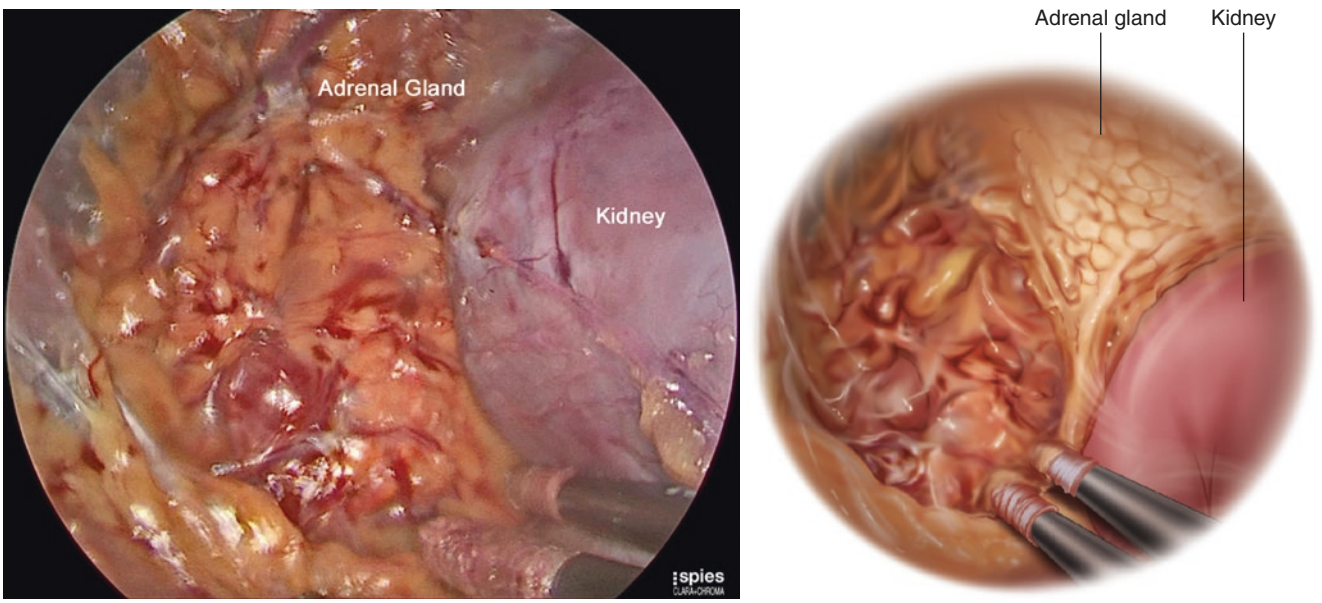

Fig. 7.5 The adrenal gland is identified, working in the cephalad direction from the kidney. One of the pheochromocytoma nodules is visualized

medial portions of the adrenal gland are mobilized with a combination of blunt and electrosurgical device dissection, with care taken to avoid bluntly injuring the adrenal vein (Figs. 7.7, 7.8, and 7.9). Lateral mobilization is then achieved (Fig. 7.10). In the case of a cortical-sparing approach, dissection around the remnant gland is minimized to preserve collateral blood supply (Fig. 7.11). If the adrenal vein has not already been identified, it is now identified and then clipped and divided, and the dissection is complete (Figs. 7.12 and 7.13). The parenchymal tissue is divided with the electrosurgical device of choice (Fig. 7.14). An endoscopic stapler may be used, but often the limited working space does not allow enough room to use the stapling device. The resected gland is placed in a specimen bag and removed. The remaining superior pole appears viable, and the surgical bed is inspected for hemostasis (Fig. 7.15).

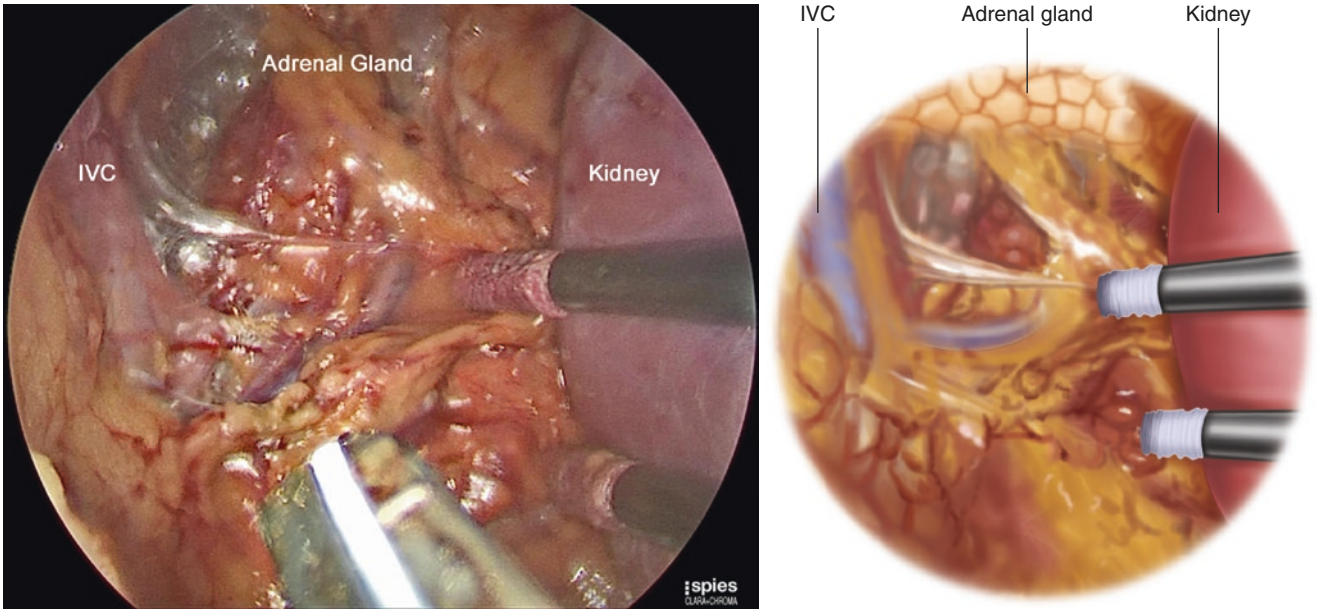

Fig. 7.6 The inferior vena cava (IVC) is identified medially

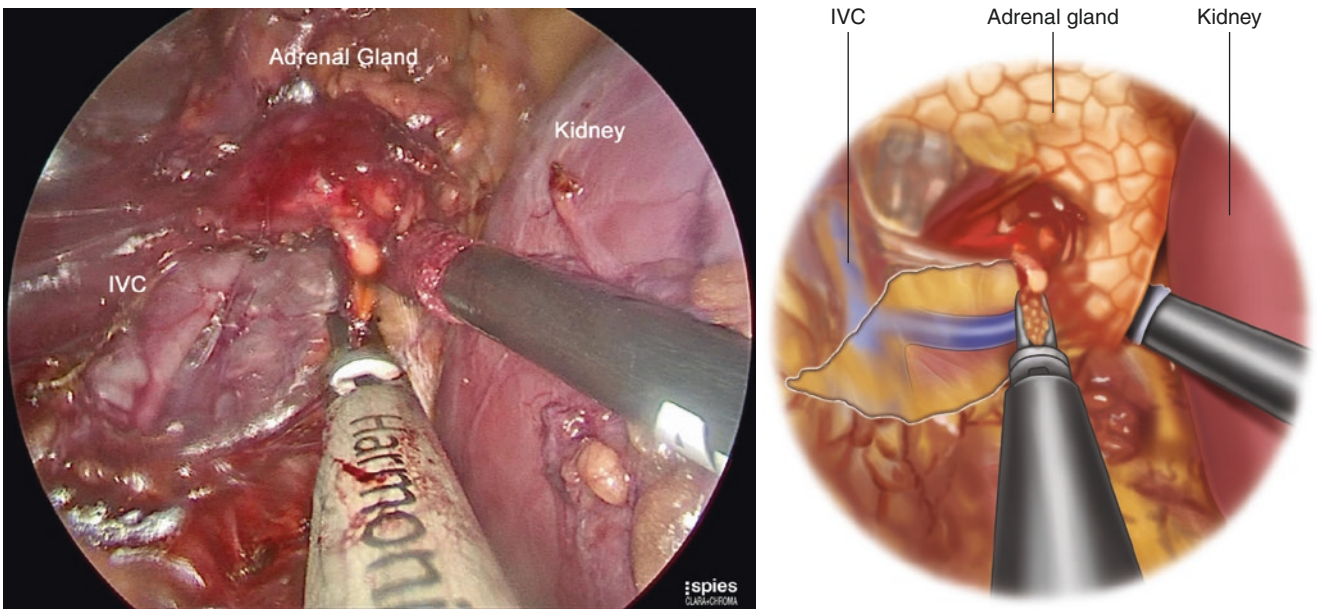

Fig. 7.7 The inferior pole of the adrenal gland is mobilized. Care is taken to avoid avulsion of the adrenal vein

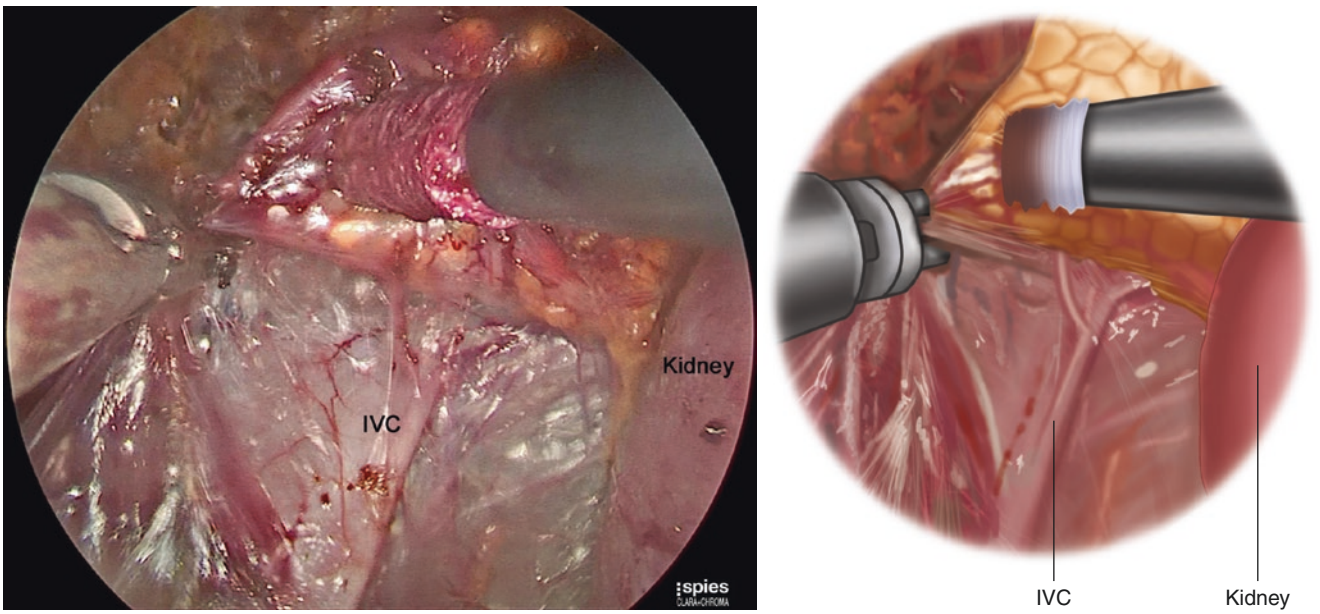

Fig. 7.8 The medial portion of the adrenal gland is mobilized, with the IVC forming the floor of the dissection

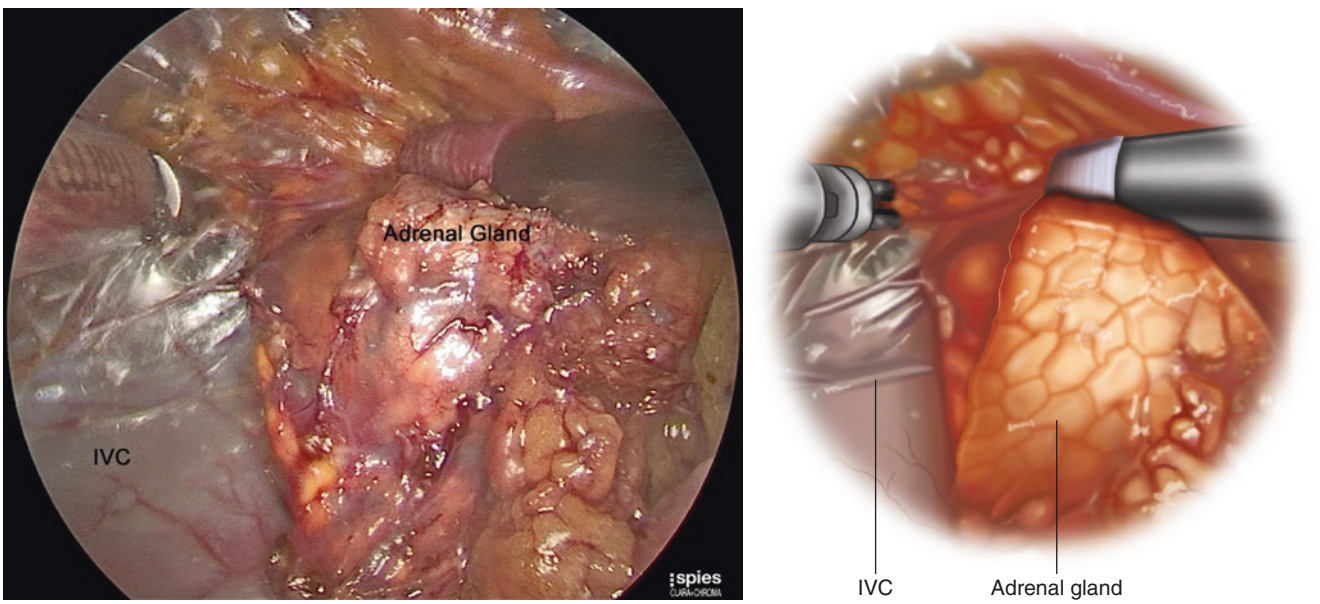

Fig. 7.9 Superior-medial dissection of the adrenal gland is continued

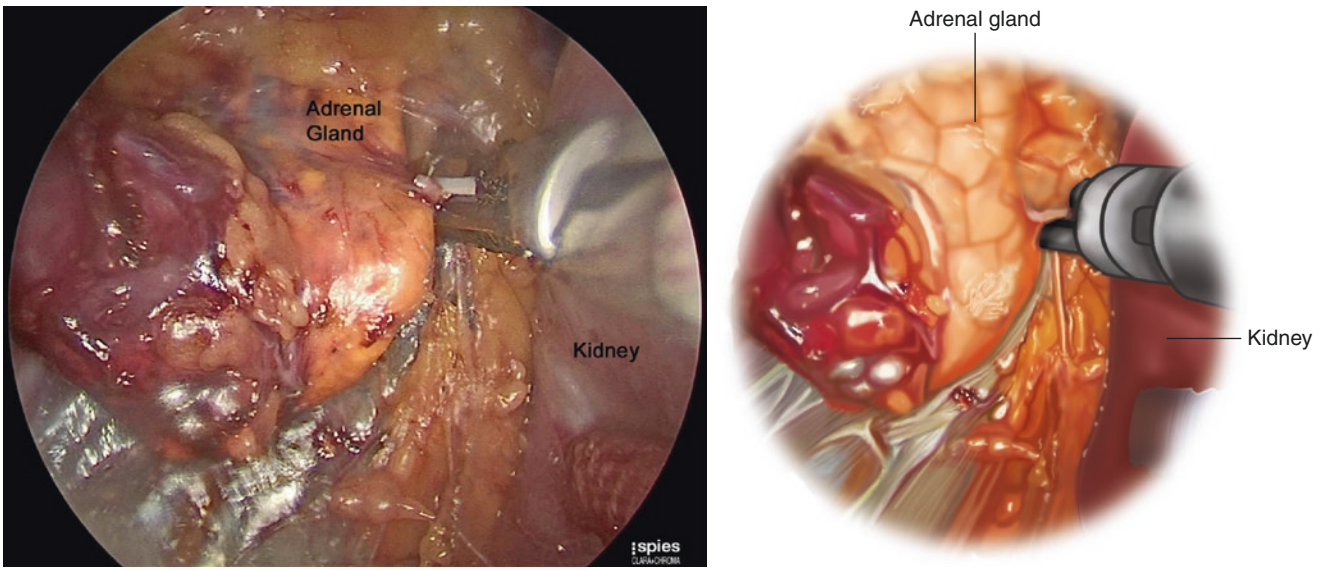

Fig. 7.10 The lateral attachments of the adrenal gland are divided

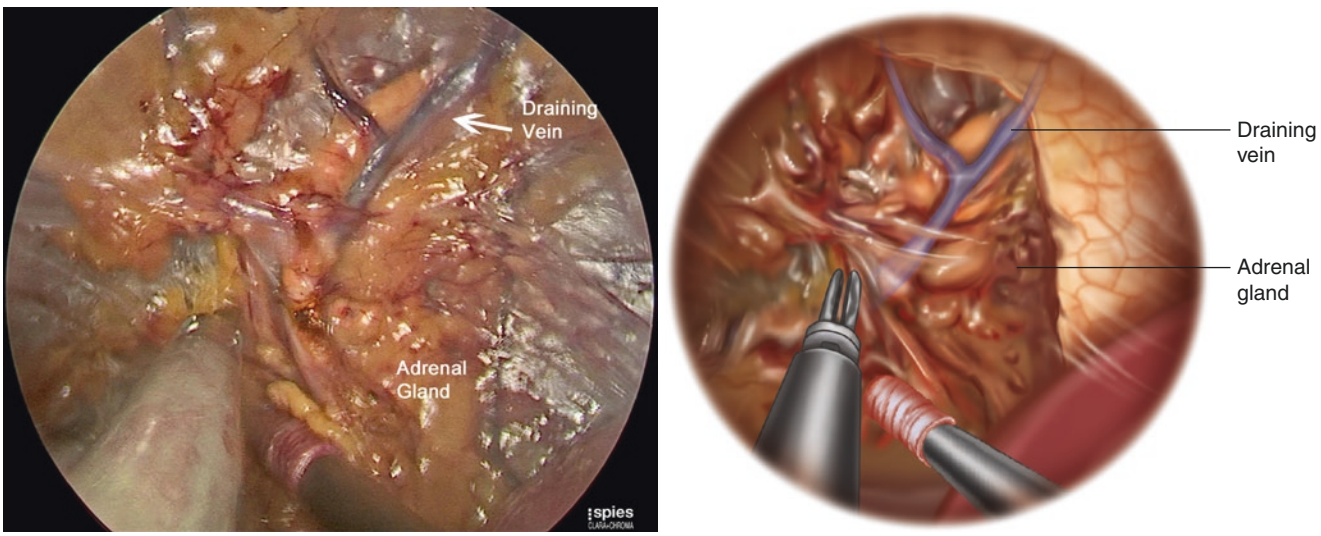

Fig. 7.11 In this case, the superior pole of the gland is free of pheochromocytoma nodules and will be spared. A large draining vein is identified and preserved

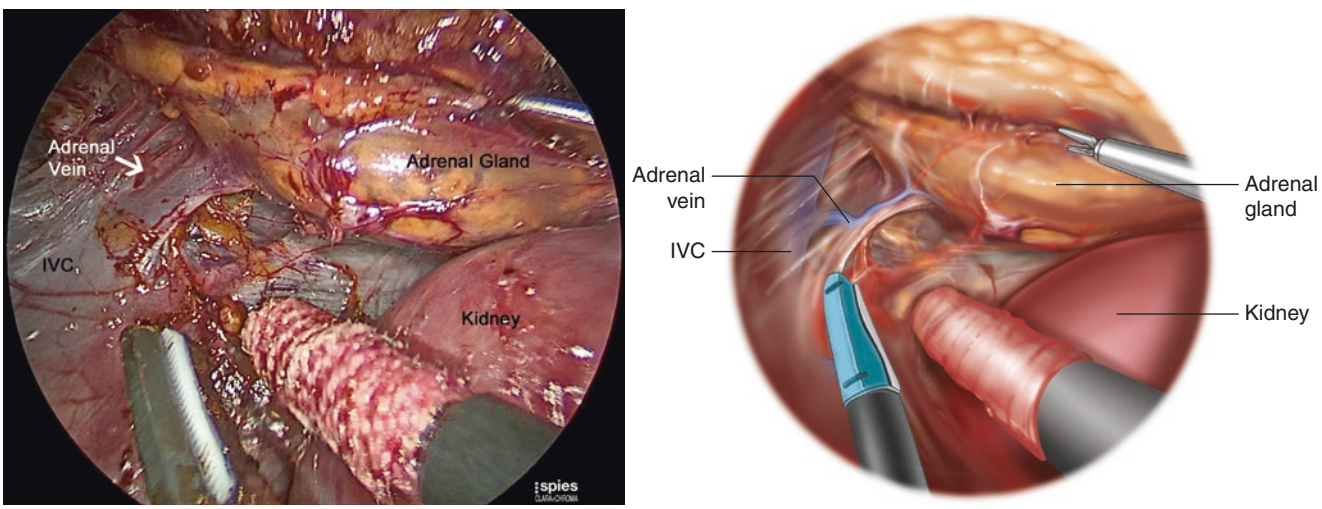

Fig. 7.12 The adrenal vein arising from the IVC is identified

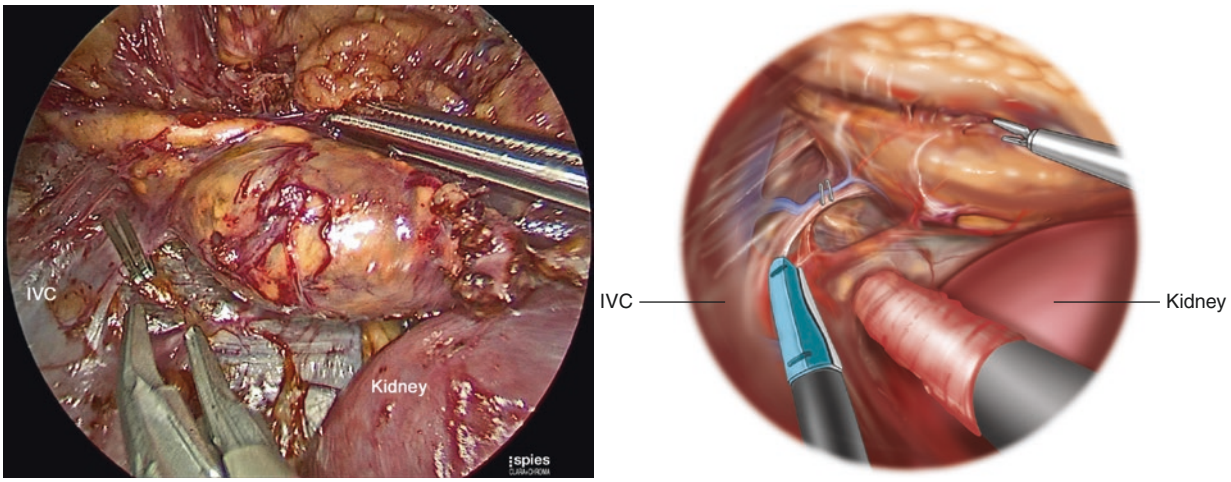

Fig. 7.13 The adrenal vein is clipped and divided

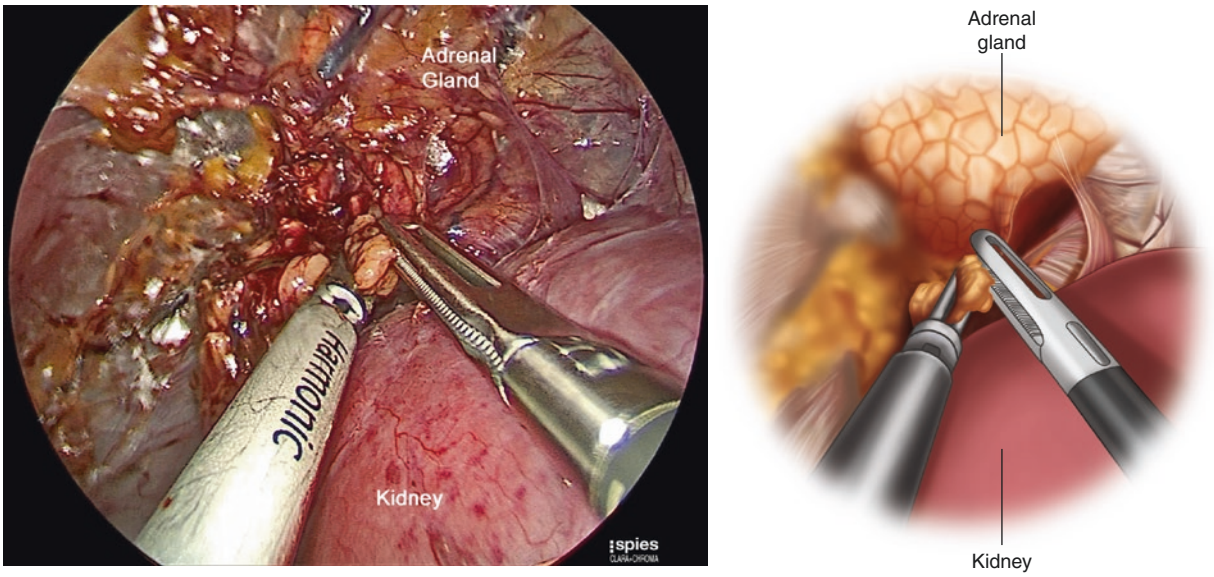

Fig. 7.14 The adrenal parenchyma is divided with the electrosurgical device

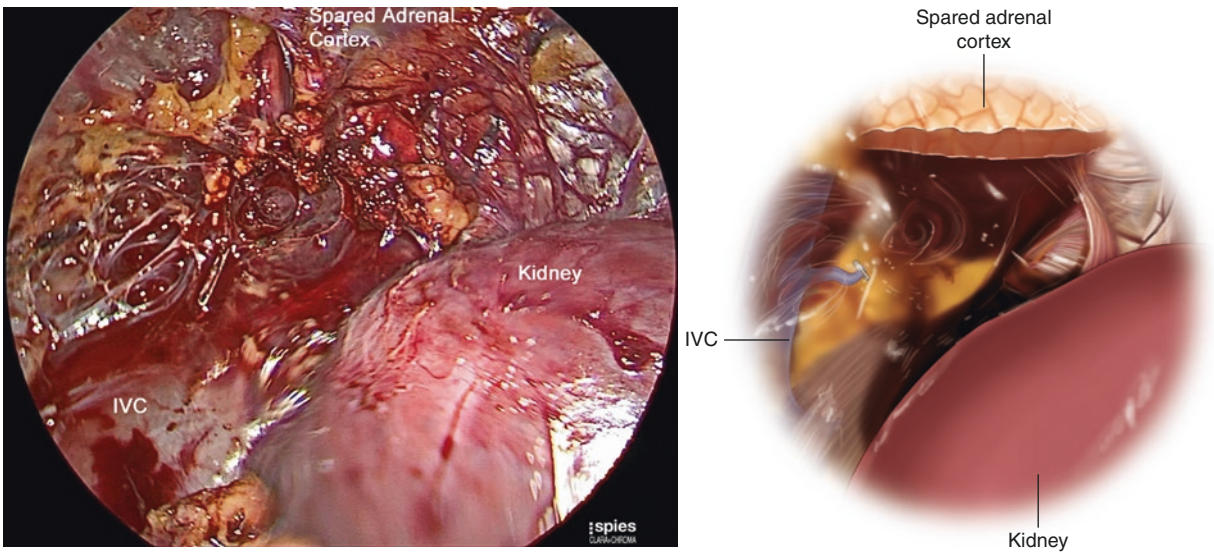

Fig. 7.15 The resection bed, with the spared superior pole of the gland visualized

Case Description

The patient is a 19-year-old gentleman with known von Hippel-Lindau syndrome. He has known retinal and central nervous system hemangioblastomata that are asymptomatic and being observed with annual imaging. His past medical history is otherwise unremarkable. He has no previous surgeries. His only regular medication is methylphenidate. He is a college sophomore. Annual biochemical screen reveals elevated normetanephrine levels (3.4 nmol/L, ref. <0.9 nmol/L) in addition to occasional headaches. Upon further questioning, his family members report that he has had increased anxiety levels recently. Cross-sectional imaging revealed unilateral, multifocal pheochromocytoma of the right adrenal gland, consisting of two nodules, with the superior pole spared (Fig. 7.16). No disease in the left gland was identified. The operation offered was a right posterior retroperitoneoscopic cortical-sparing adrenalectomy. This approach, when used in patients with hereditary pheochromocytoma, has resulted in excellent outcomes with limited unilateral recurrences [3]. With this approach, the risk of unilateral recurrence in the cortical-sparing remnant was 7%. The incidence of subsequent pheochromocytoma in the contralateral side was 30%. The cortical-sparing approach allows for preserved steroid synthetic function in most patients, even in patients who develop contralateral

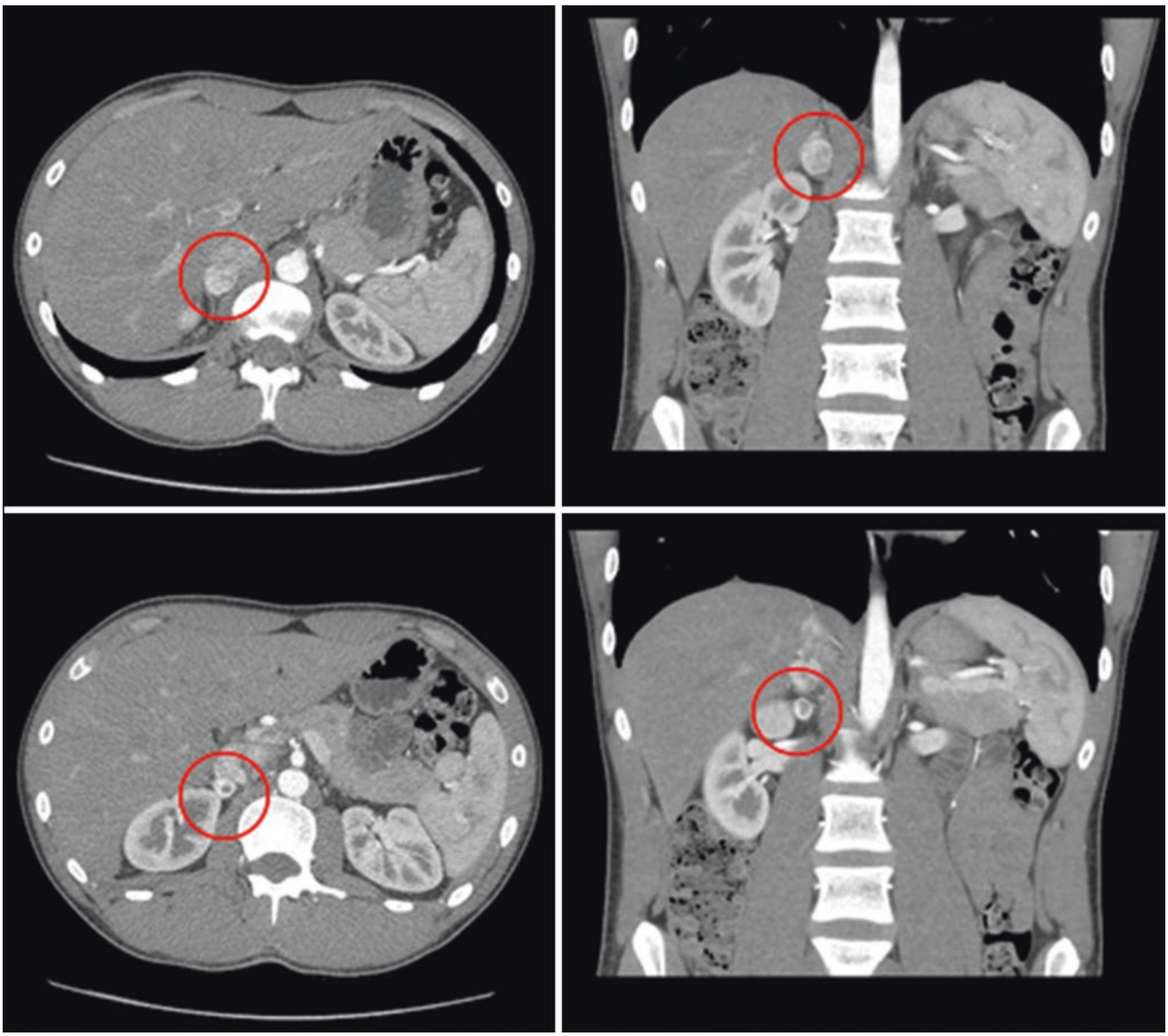

Fig. 7.16 Computed tomography, contrast-enhanced imaging, with two distinct nodules in the right adrenal gland, indicated by the red circles

pheochromocytoma. In this series, 78% of patients were steroid independent at 3-year follow-up. The rationale is to perform a cortical-sparing adrenalectomy when possible, so that a future recurrence that requires a total adrenalectomy will not render the patient completely steroid dependent.

The patient initiated alpha-blockade with doxazosin 3 weeks prior to his scheduled operation. The initial dose was 0.5 mg nightly; no dose adjustments were necessary. He was also advised to salt load for a few days prior to surgery. No beta-blockade was necessary. His blood pressure changes and symptoms were monitored by clinic staff on an outpatient basis. His operation was performed as described above. He was discharged the following day, and his recovery has been without incident. His final pathology revealed two pheochromocytoma tumors, 2.2 and 1.5 cm in size.

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Left Robotic Transperitoneal Adrenalectomy

8

Claire Nomine-Criqui, Cyrille Buisset, Laurent Bresler, and Laurent Brunaud

A 59-year-old woman underwent an adrenal screening for hirsutism (face, chest). She had no clinical signs of hypercorticism. Laboratory investigations demonstrated increased plasma testosterone levels (twice the upper normal limit) and a markedly increased SDHEA level (ten times upper normal limit). Urinary free cortisol level was normal. Imaging studies showed a left adrenal mass of about 5 cm consistent with a cortical tumor without aggressive imaging characteristics. Contralateral adrenal gland and ovaries were normal. FDG-PET scan showed a moderate uptake at the left adrenal gland (tumor/liver SUV ratio = 2.1).

Video 8.1 shows different steps that would be necessary to complete a totally robotic lateral transperitoneal left adrenalectomy. The patient was placed in right lateral decubitus position, flexed at the waist. An "open" left subcostal access was used to introduce a 12-mm optical trocar. Under laparoscopic vision (0° scope), four other trocars were introduced: two 8-mm left subcostal trocars, one 5-mm trocar, and one 10-mm trocar for the first assistant's left and right hands, respectively, in a lower left subcostal position. The robot (da Vinci® Si Surgical System, Intuitive Surgical) was placed at the patient's left shoulder and was docked. The first step of the procedure was the mobilization of the body and tail of the pancreas in order to medially retract the splenopancreatic block (Figs. 8.1, 8.2, 8.3, and 8.4). The left large adrenal mass was identified, and Gerota's fascia was incised (Figs. 8.5, 8.6, and 8.7). Articulated instruments were used to free the adrenal mass from the body and tail of the pancreas with direct visualization of splenic vessels. Then, the left renal vein was accurately dissected, and the main adrenal vein was identified (Figs. 8.8, 8.9, 8.10, 8.11, and 8.12). To obtain an adequate control on the adrenal mass during the main adrenal vein preparation, the inferior-lateral aspect of the adrenal gland was first dissected en bloc with the perinephric fat, from the renal vein and from the upper pole of the kidney (Figs. 8.13, 8.14, 8.15, 8.16, and 8.17). This step allowed better exposure of the main adrenal vein, which was subsequently dissected, clipped with robotic nonabsorbable self-locking clips (Hem-o-lok®, Weck-Telefex Europe Ltd.), and divided (Figs. 8.18, 8.19, 8.20, 8.21, 8.22, and 8.23). Then the adrenal mass was completely dissected and mobilized from the posterior muscular plane (iliopsoas) and finally carefully separated from the stomach using a monopolar hook and bipolar grasp (Figs. 8.24, 8.25, and 8.26). The specimen was put in a plastic bag and extracted through the enlarged first assistant's port (Fig. 8.27). The overall operative time was 90 minutes. No postoperative complications were observed, and hospitalization duration was 2 days. Final histology showed an adrenal cortical tumor, with a Weiss score of 1, 5.1 cm in its maximum diameter, without capsular effraction. Testosterone and SDHEA levels were normalized postoperatively and remained normal at the patient's 2-year follow-up. Hirsutism has improved postoperatively but did not disappear. Minimally invasive laparoscopic adrenalectomy has replaced open adrenalectomy as the standard technique for the management of most adrenal surgical disorders [1]. Robot-assisted approach for adrenalectomy represents a technical evolution from conventional laparoscopy and allows surgeons to achieve minimally invasive access [2].

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_8) contains supplementary material, which is available to authorized users.

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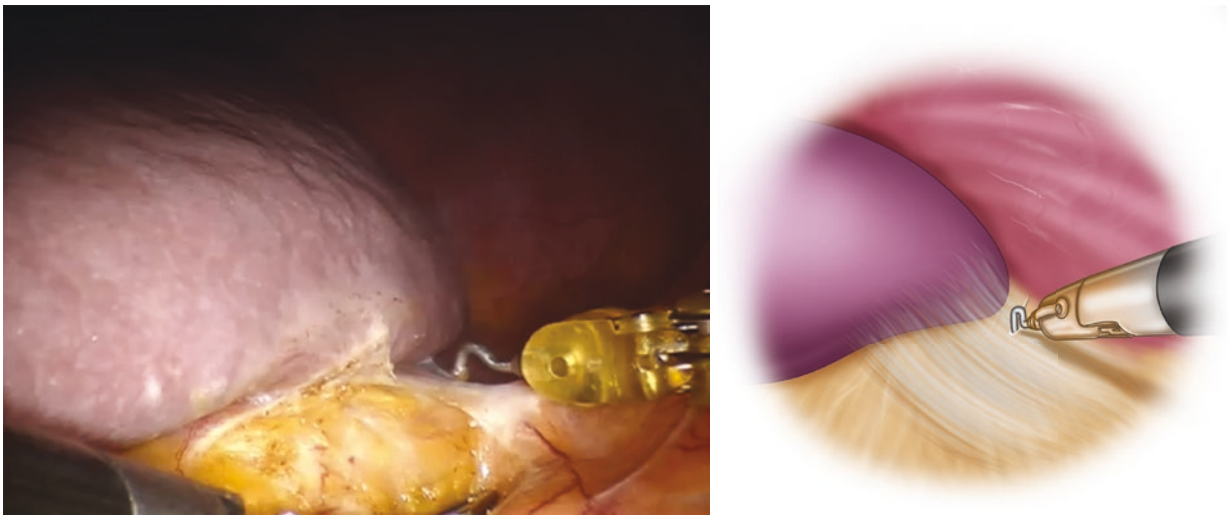


Fig. 8.1 Dissection and opening of the peritoneum lateral to the spleen

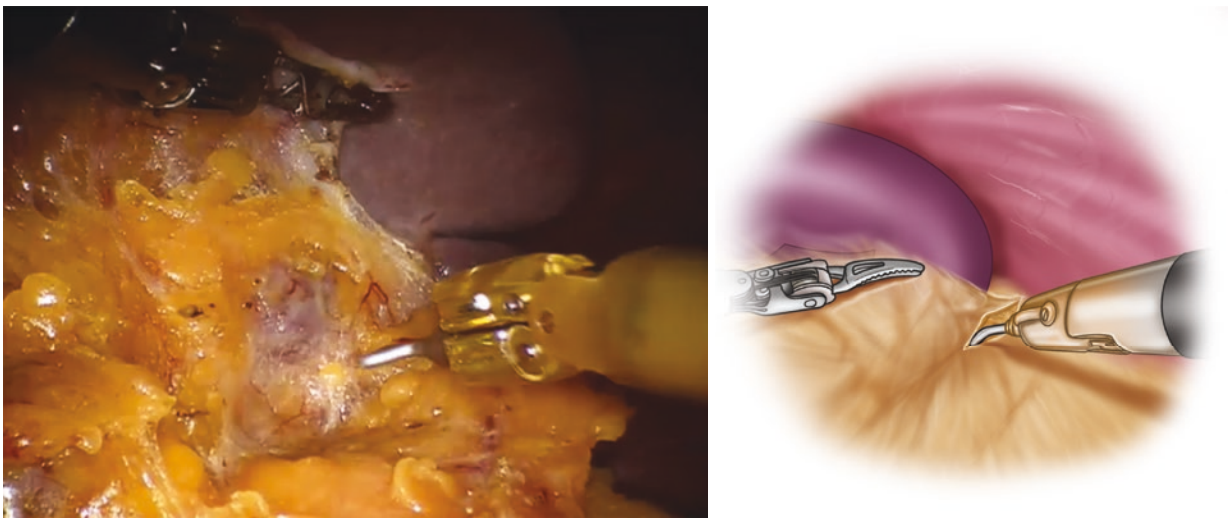


Fig. 8.2 Posterior dissection behind the pancreatic tail and spleen mobilization

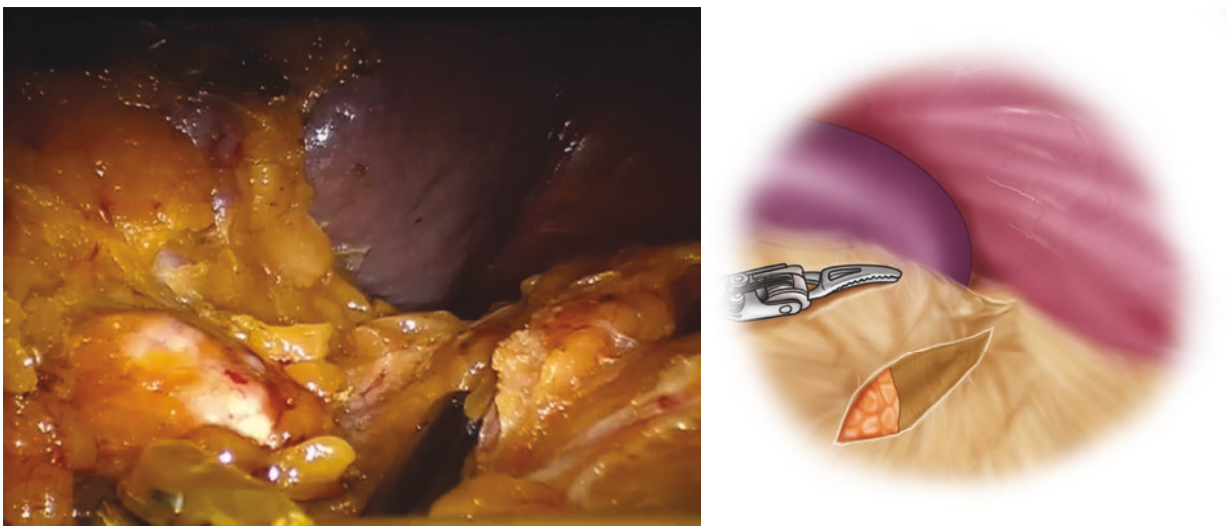


Fig. 8.3 Beginning of pancreatic tail posterior

Fig. 8.4 Pancreatic tail posterior dissection

Fig. 8.5 Pancreatic tail posterior dissection with visualization of the splenic artery

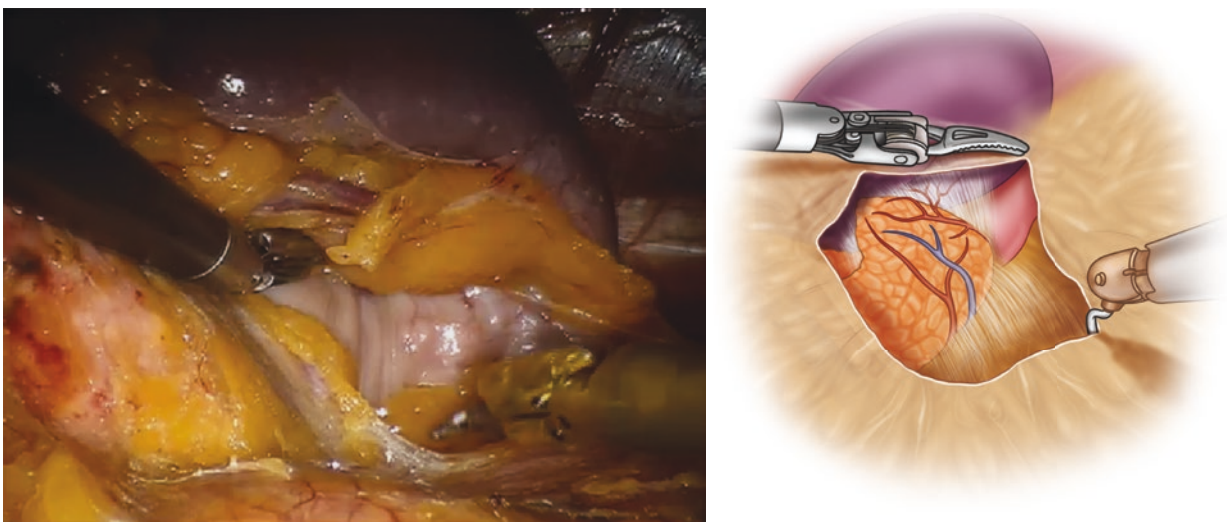


Fig. 8.6 Posterior pancreatic dissection and spleen mobilization allowing exposure of the posterior aspect of the stomach

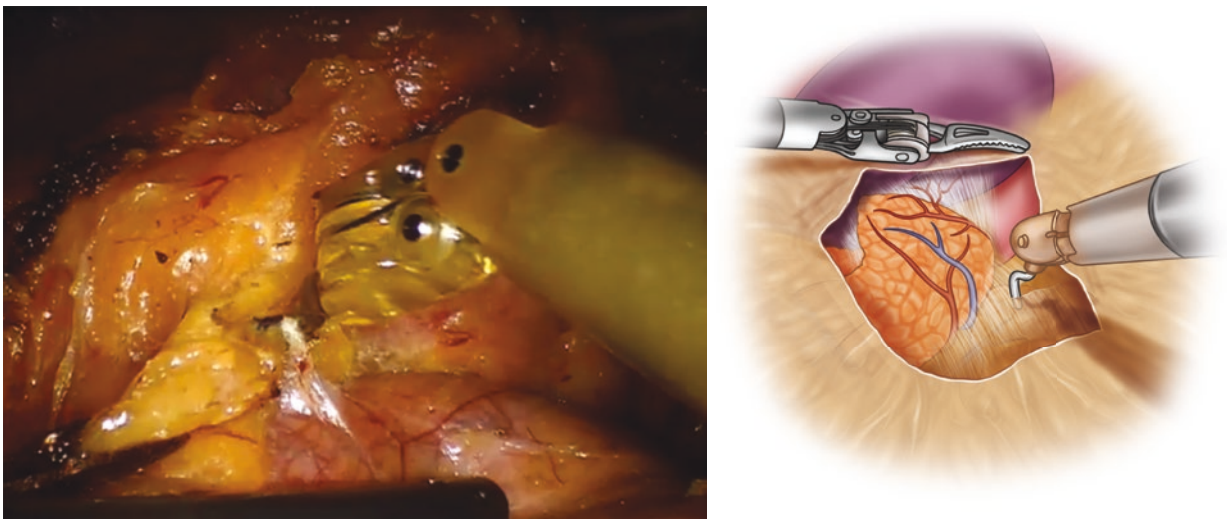


Fig. 8.7 Beginning of the dissection between the pancreas and the left adrenal gland

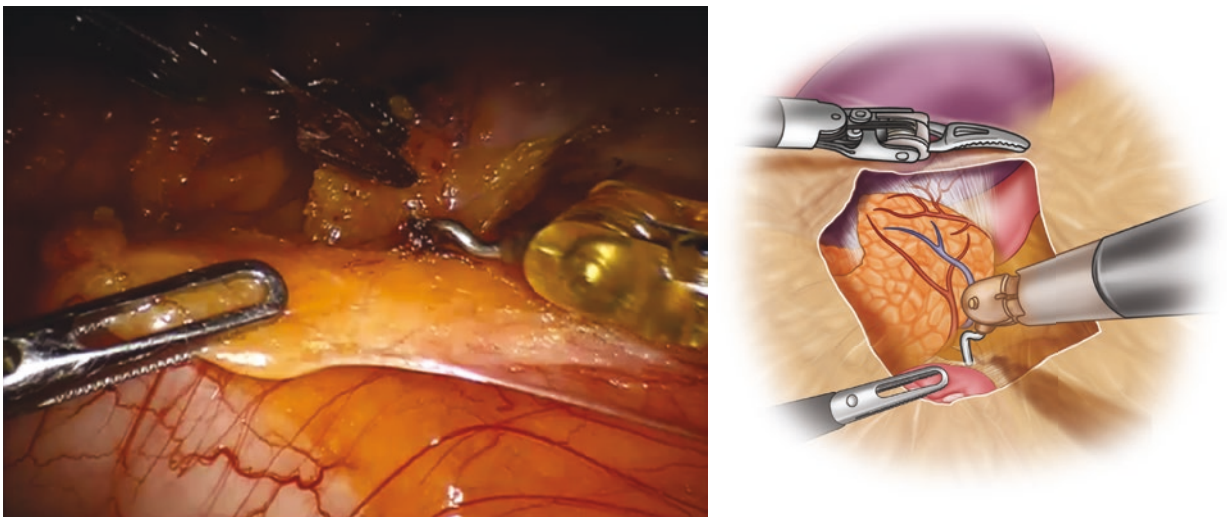


Fig. 8.8 Inferior dissection allowing mobilization of the left colon flexure

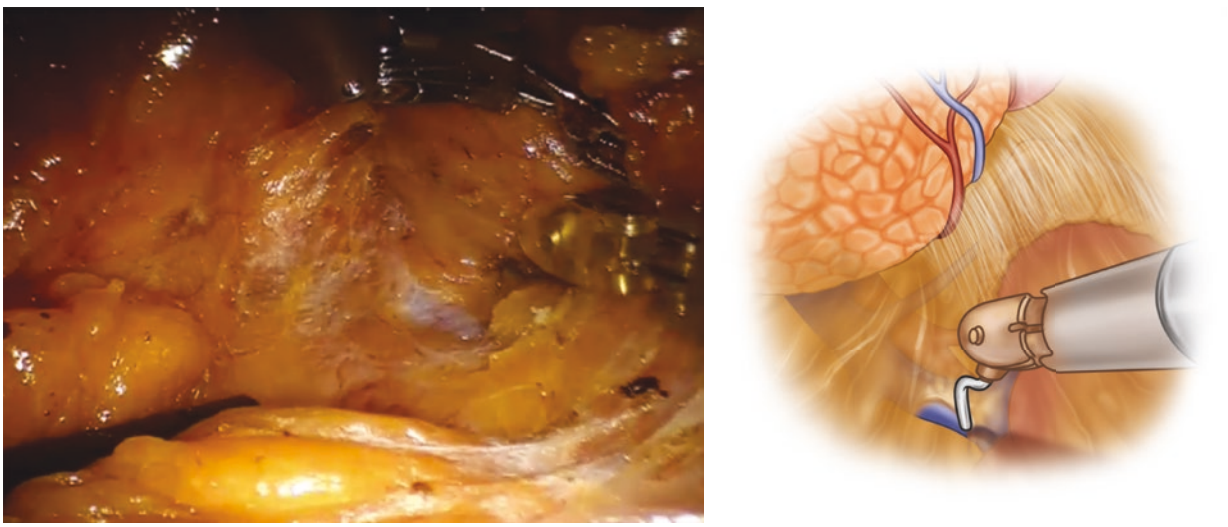


Fig. 8.9 Inferior dissection allowing exposition of the left renal vein

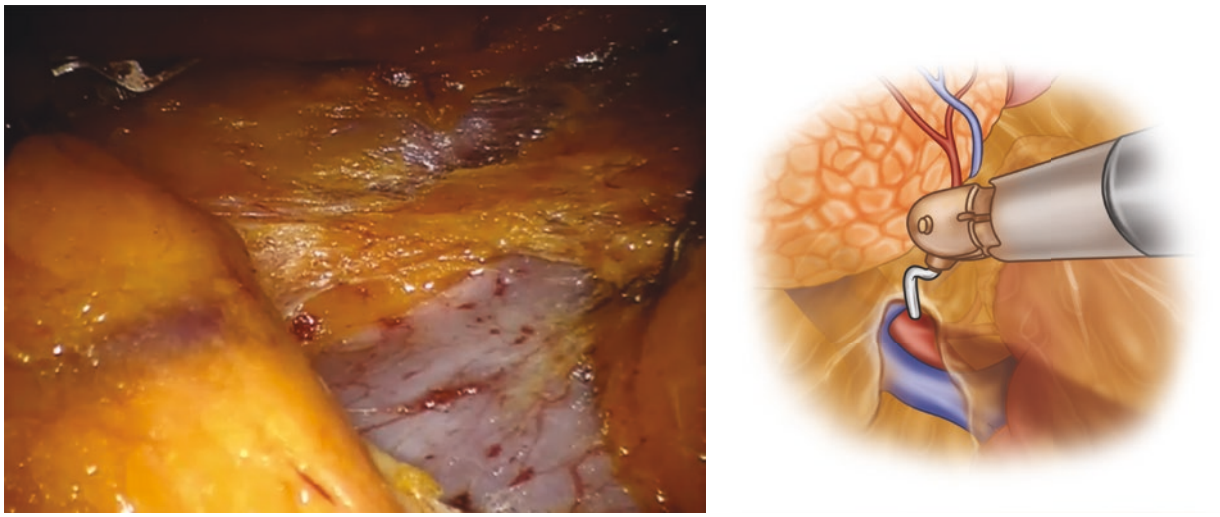


Fig. 8.10 Dissection of the left renal vein (upper aspect) allowing to expose the main adrenal vein

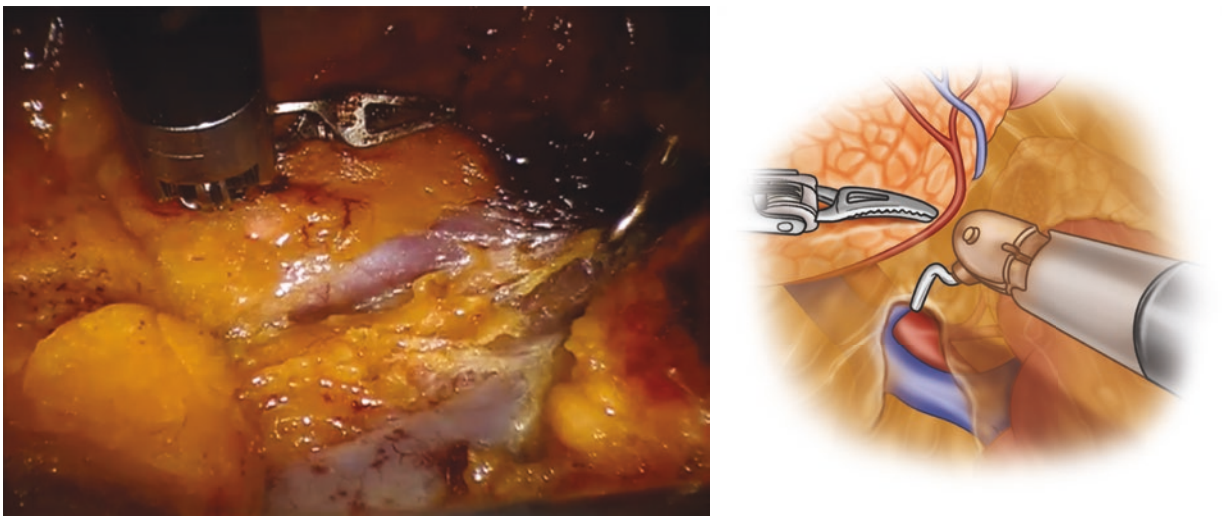


Fig. 8.11 Further pancreatic tail posterior dissection with visualization of the splenic artery and vein

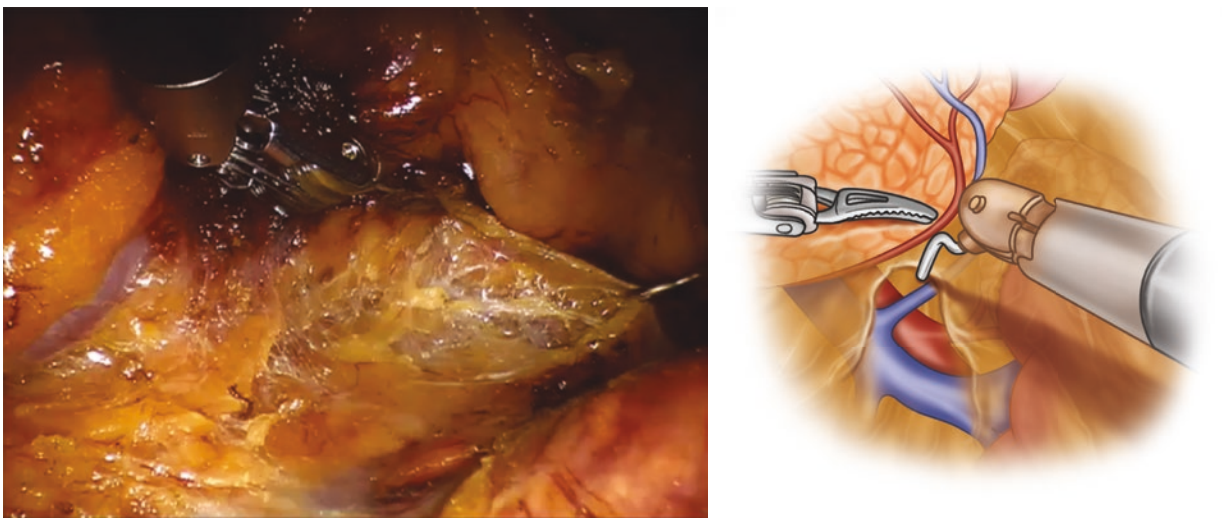


Fig. 8.12 End of retropancreatic dissection with adrenal tumor visualized at the right lower corner

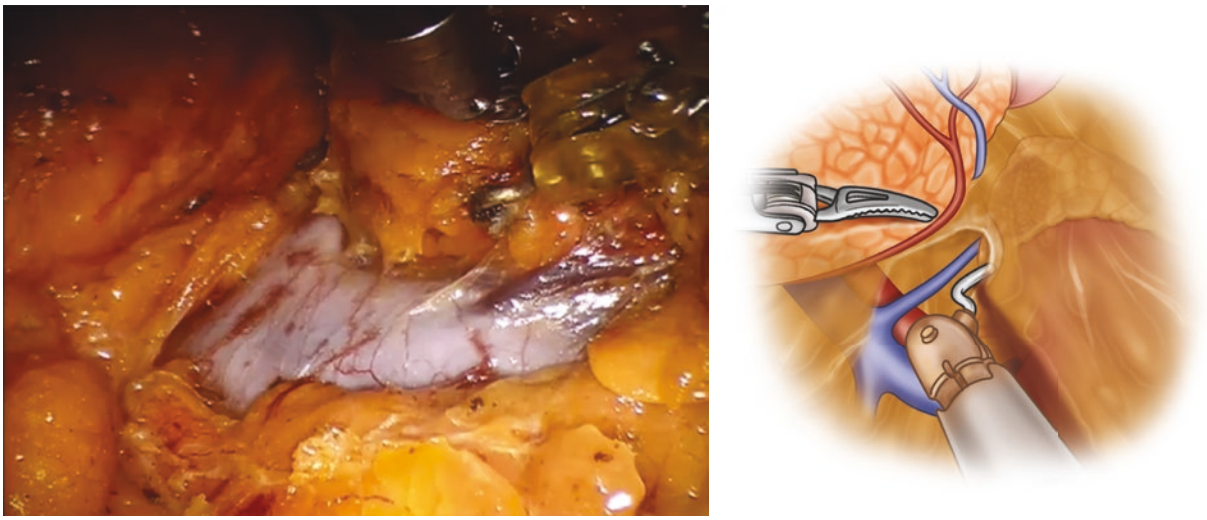


Fig. 8.13 Final view of the exposition of the left renal and main adrenal veins

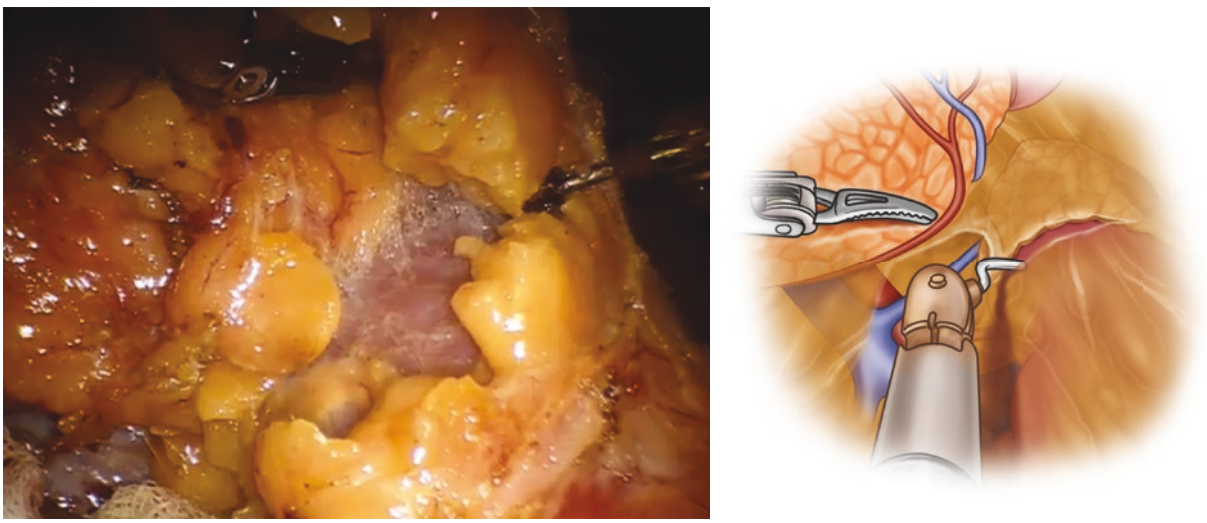


Fig. 8.14 Dissection of the upper pole of the left kidney

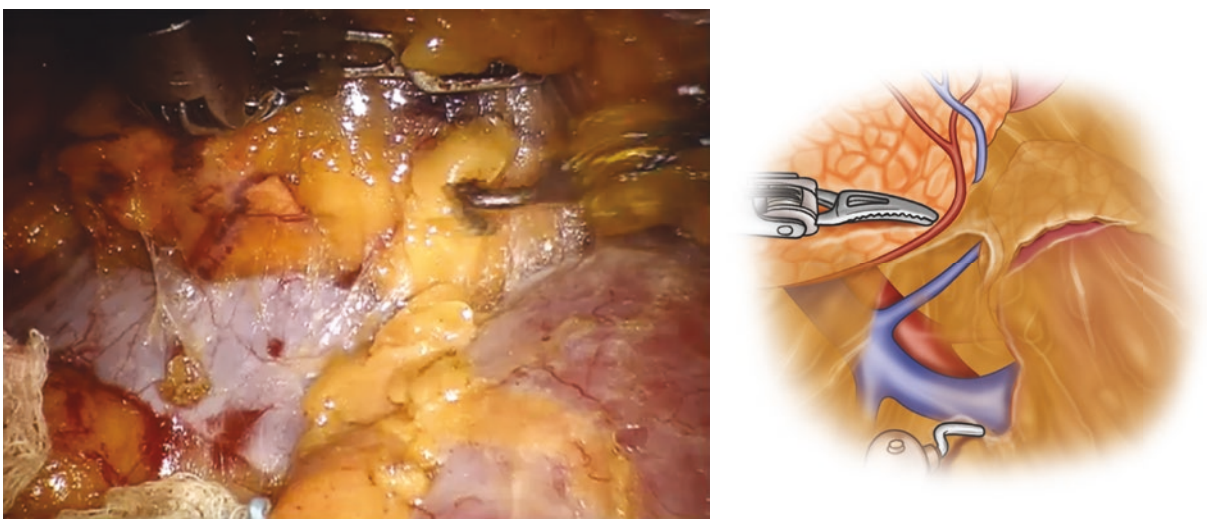


Fig. 8.15 Complete exposition of the left renal vein (upper aspect)

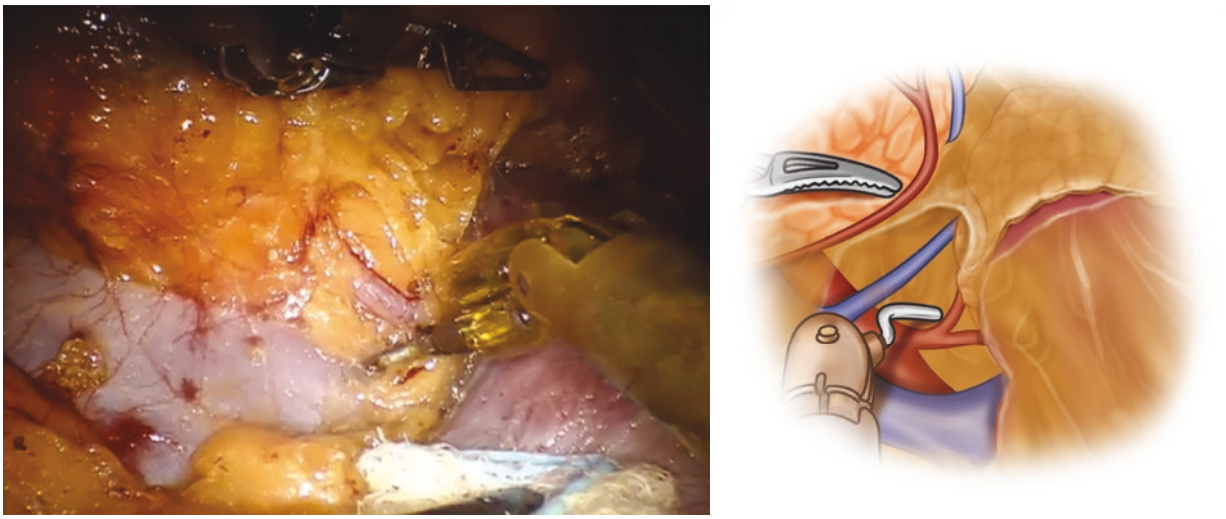


Fig. 8.16 Dissection of an accessory renal artery

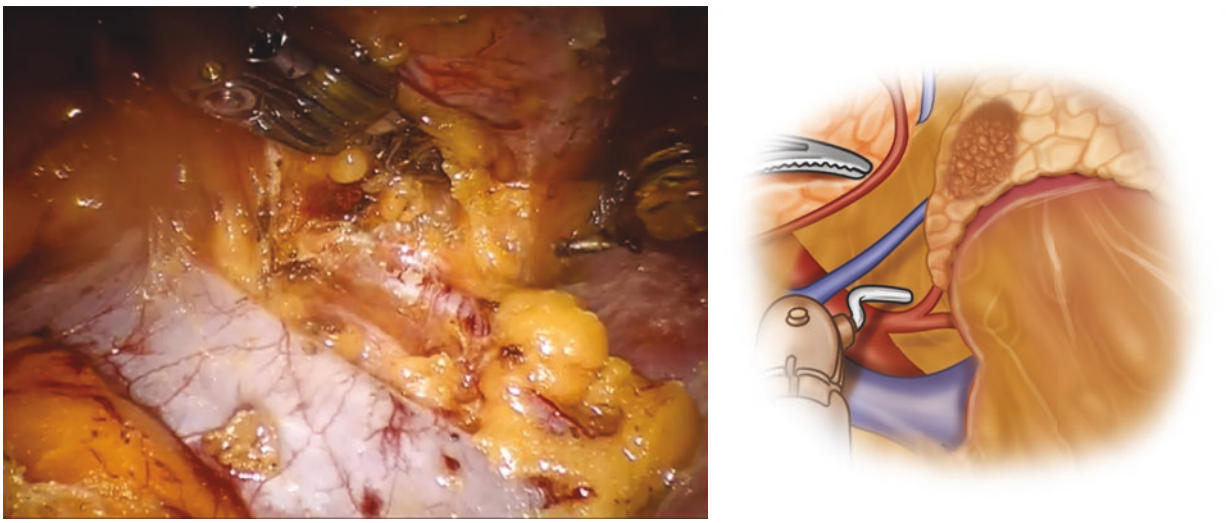


Fig. 8.17 Dissection between the left renal vein with an accessory renal artery (below) and the lower part of the adrenal tumor (above)

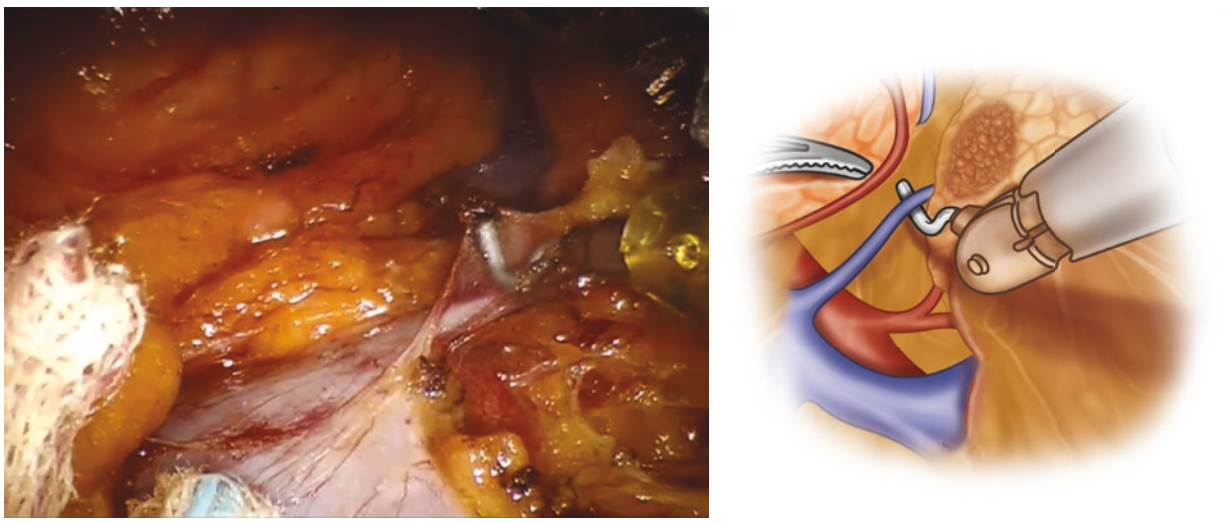


Fig. 8.18 Dissection around the left main adrenal vein

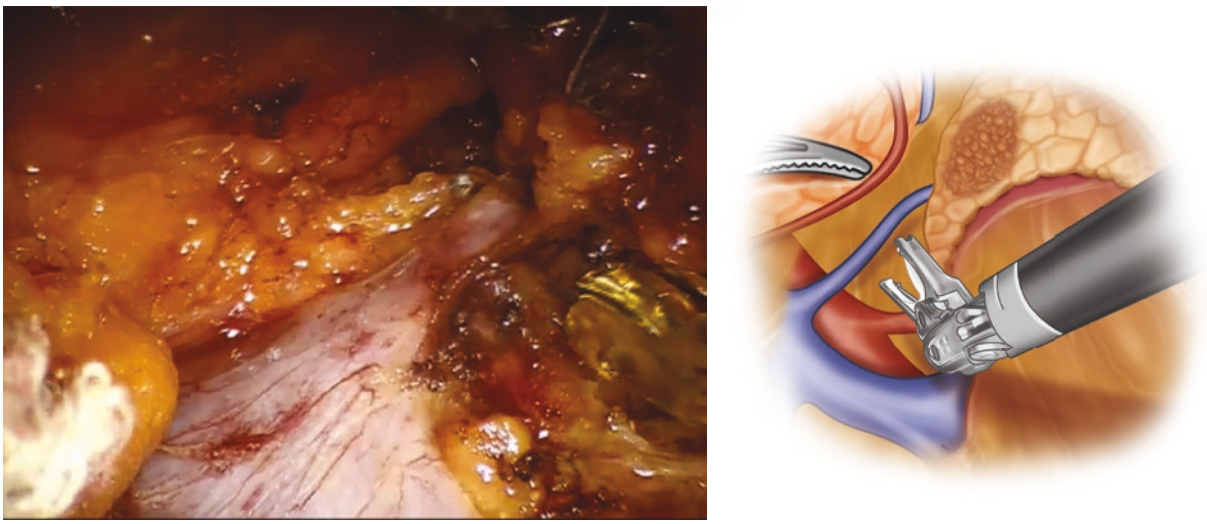


Fig. 8.19 Preparation to clip the left main adrenal vein

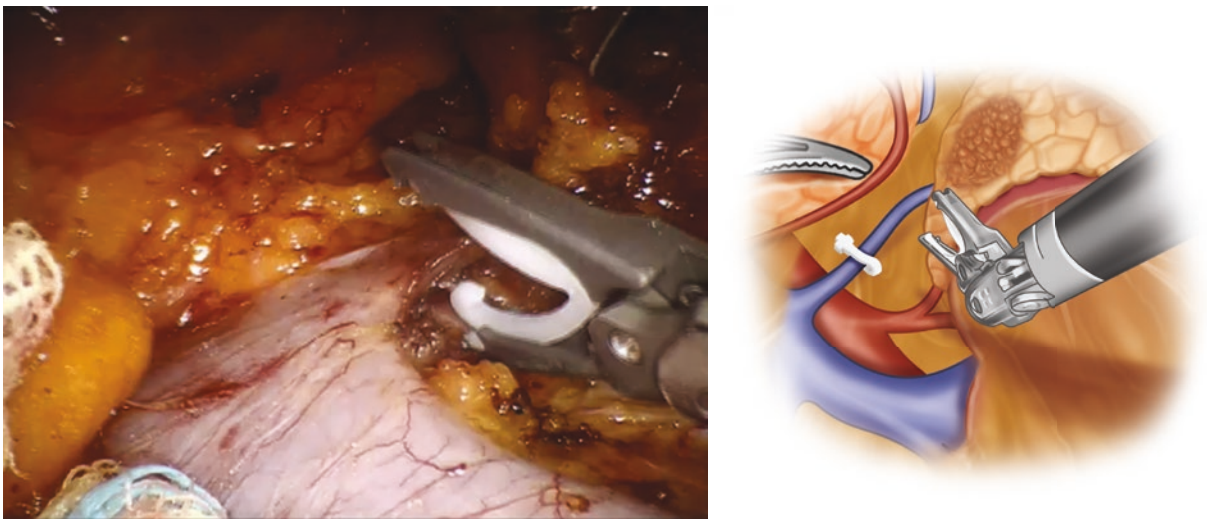


Fig. 8.20 Application of the clip proximal to the left renal vein

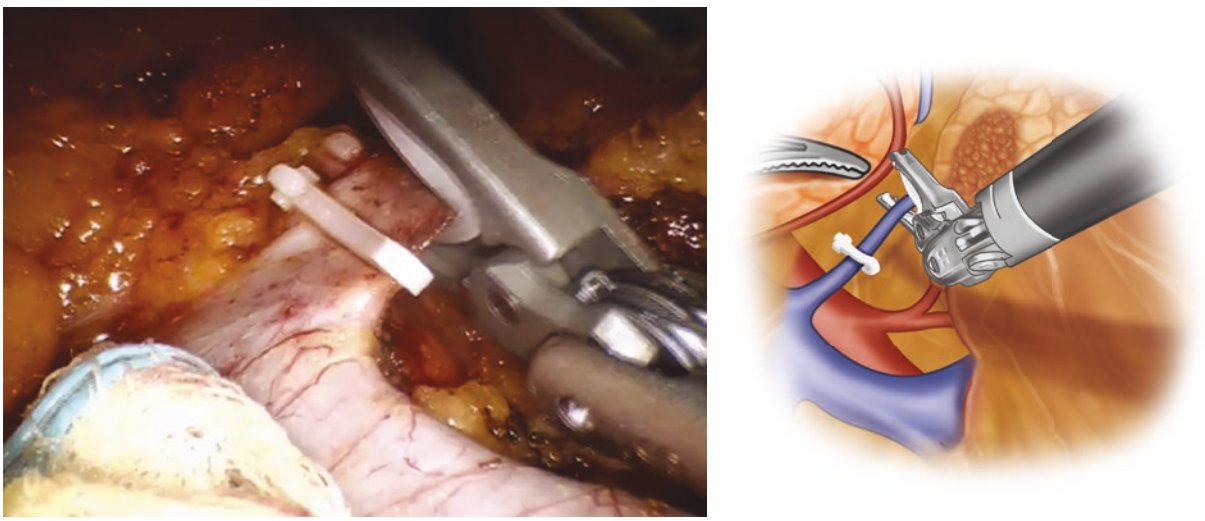


Fig. 8.21 Application of the clip proximal to the adrenal tumor

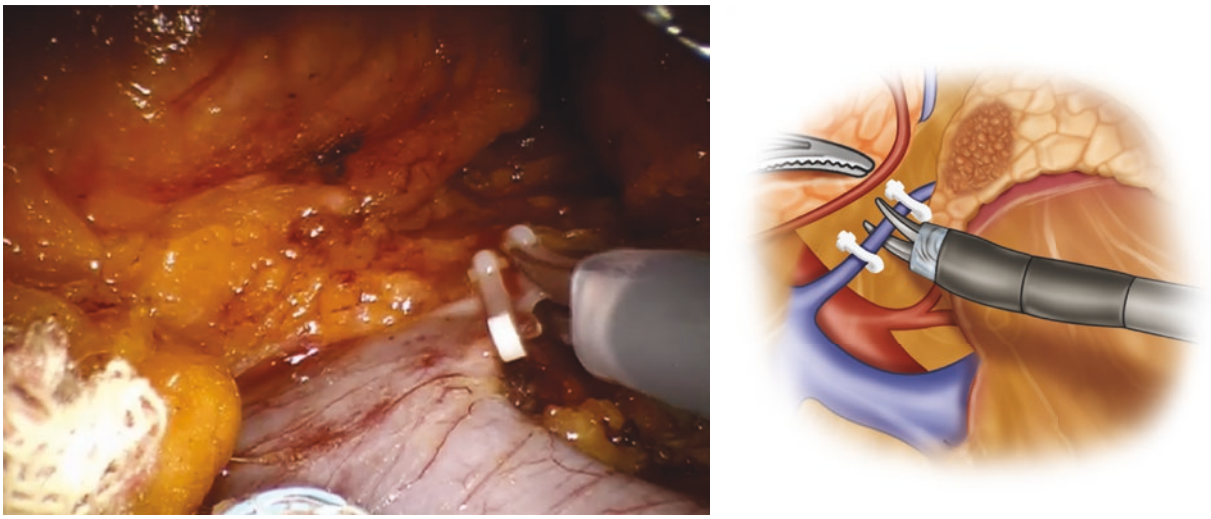


Fig. 8.22 Transection of the left main adrenal vein between the two clips

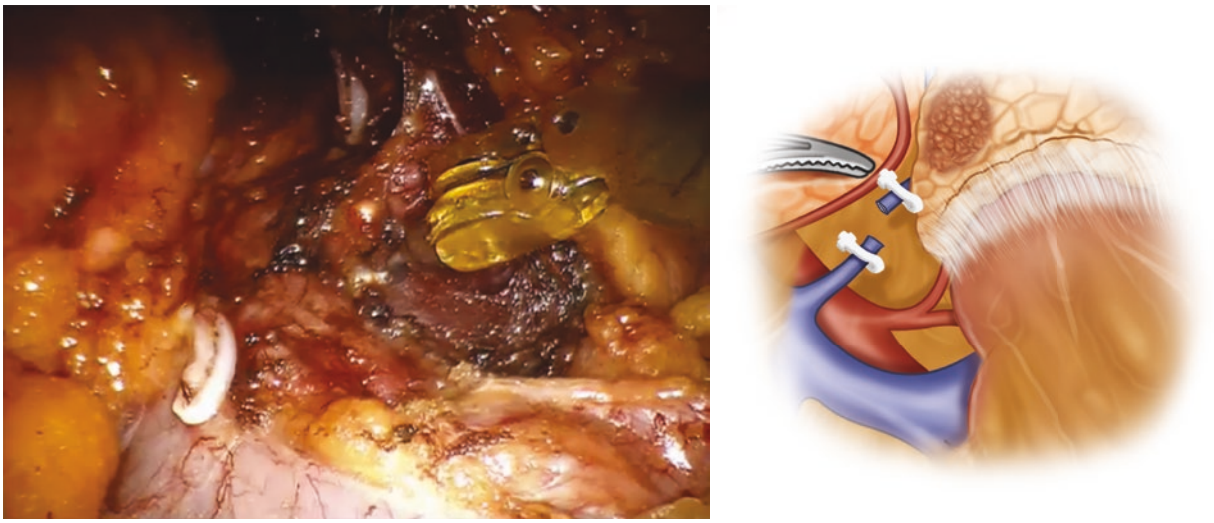


Fig. 8.23 Posterior dissection behind the adrenal tumor (close to the iliopsoas muscle)

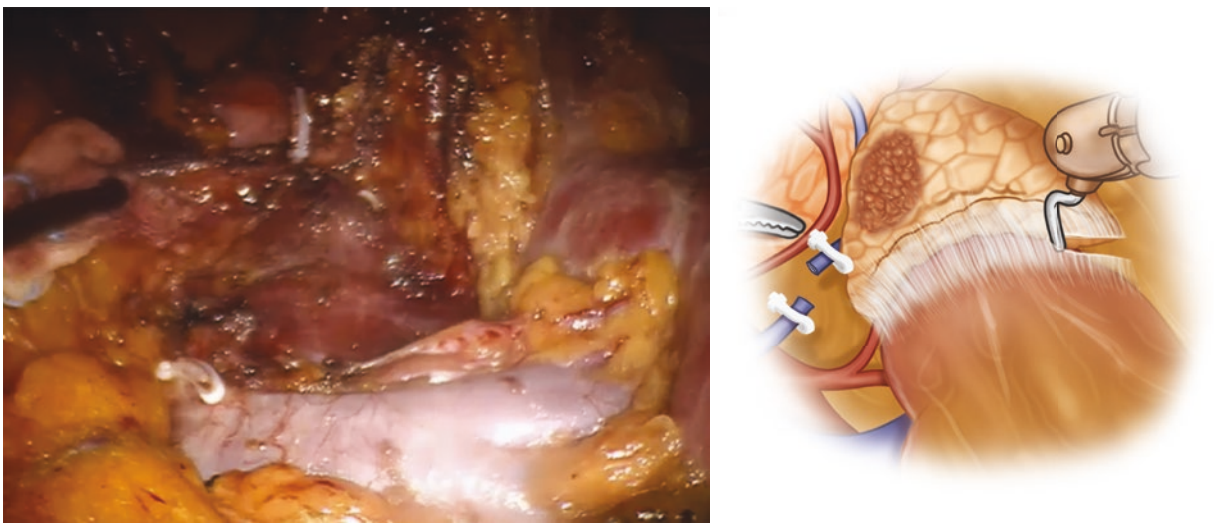
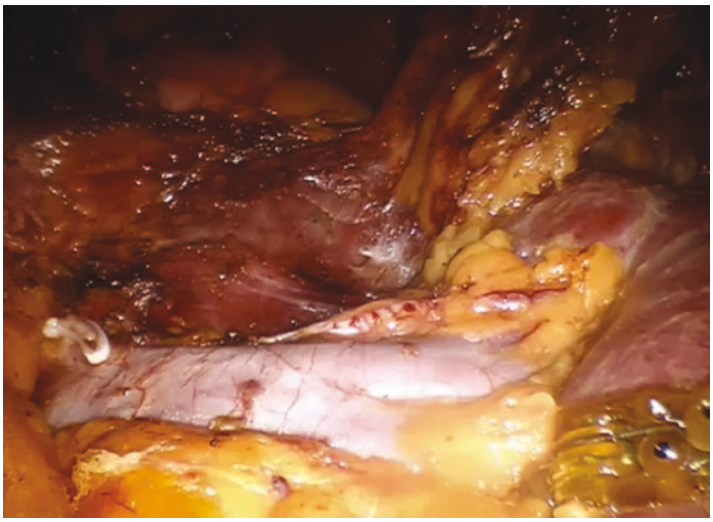


Fig. 8.24 General view just before the end of the dissection



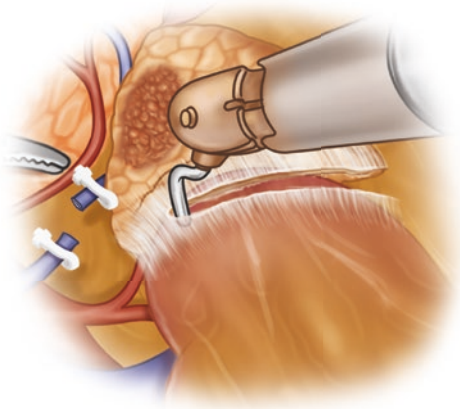
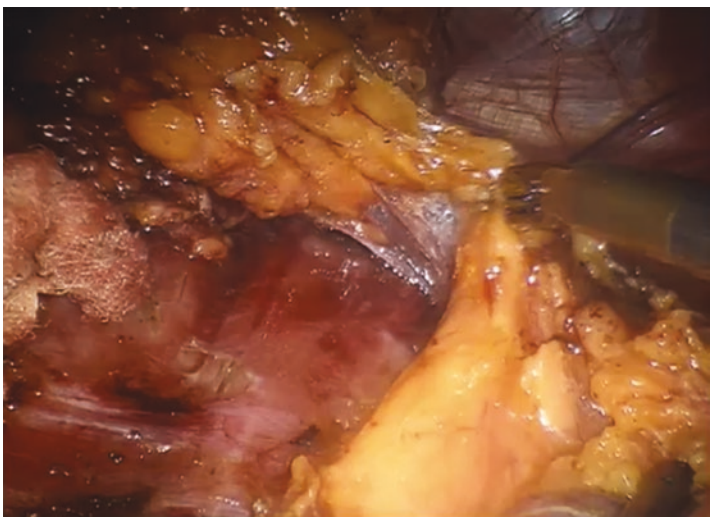


Fig. 8.25 General view before ending the dissection



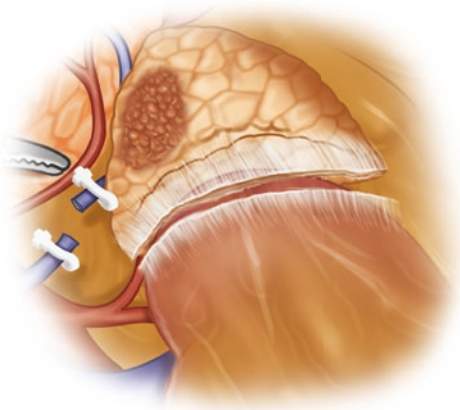
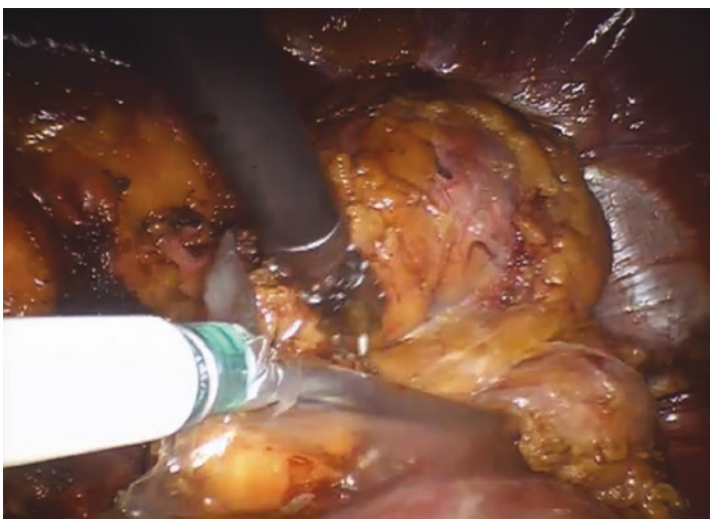


Fig. 8.26 Final dissection



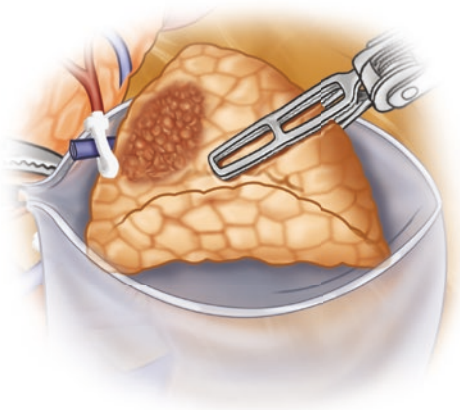


Fig. 8.27 Specimen extracted using an Endo Catch bag

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Right Robotic Transperitoneal Adrenalectomy

9

Claire Nomine-Criqui, Camille Gaulier, Marc Klein, and Laurent Brunaud

A 49-year-old woman underwent a medical evaluation for a right adrenal incidentaloma. Laboratory investigations were within normal ranges and ruled out the diagnosis of functional adrenal tumor. CT scan showed a 4.2-cm right adrenal tumor compatible with a cortical adrenal adenoma. FDG-PET scan showed a left adrenal tumor with moderate uptake (tumor/liver SUV ratio = 2.5).

After multidisciplinary evaluation, a totally robotic lateral transperitoneal right adrenalectomy was performed. The patient was placed in the left lateral strict decubitus position and flexed at the waist. An "open" right subcostal access was used to introduce a 12-mm optical trocar. Under laparoscopic vision (0° scope), four other trocars were introduced: two 8-mm right subcostal trocars, one 12-mm trocar, and one 10-mm trocar for the first assistant's left and right (liver retractor) hands, respectively. The robotic cart (da Vinci® Si Surgical System, Intuitive Surgical) was placed above the patient's right shoulder and was docked.

Intra-abdominal exploration confirmed the presence of a retroperitoneal mass. The right triangular ligament was divided, and the liver was medially retracted (Figs. 9.1, 9.2, and 9.3). The right aspect of the vena cava was exposed. The right adrenal was first dissected, en bloc, with the periadrenal fat. The direction started at the upper pole of the kidney and from the lateral attachments in order to obtain an adequate mobilization of the adrenal mass. This also allowed it to be rotated to provide a better approach to the right lateral and posterior aspects of the vena cava. Then, dissection was carried out progressively upward along the inferior vena cava on the medial margin of the tumor (Figs. 9.4 and 9.5). The main adrenal vein was dissected, clipped using nonabsorbable self-locking clips (Hem-o-lok®, Weck-Telefex Europe Ltd.), and divided (Figs. 9.6, 9.7, 9.8, and 9.9).

The adrenal mass was completely dissected and mobilized from its posterior aspect (iliopsoas muscle) (Figs. 9.10, 9.11, 9.12, 9.13, 9.14, 9.15, and 9.16). Overall operative time was 45 min. No postoperative complication was observed, and hospitalization duration was 3 days. Final pathology confirmed the diagnosis of adrenocortical adenoma measuring 4.1 cm in diameter with a Weiss score 0 without capsular effraction (Fig. 9.17). Video 9.1 clearly demonstrates different steps required to perform a right adrenalectomy in a patient with a large adrenal tumor but without adjacent organ extension [1]. In some specific conditions (e.g., large adrenal tumors, or in obese patients), articulated instruments, 3D vision, and ergonomic position of the surgeon provided by the robotic system could help to perform accurate dissection and safe resection [2].

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_9) contains supplementary material, which is available to authorized users.

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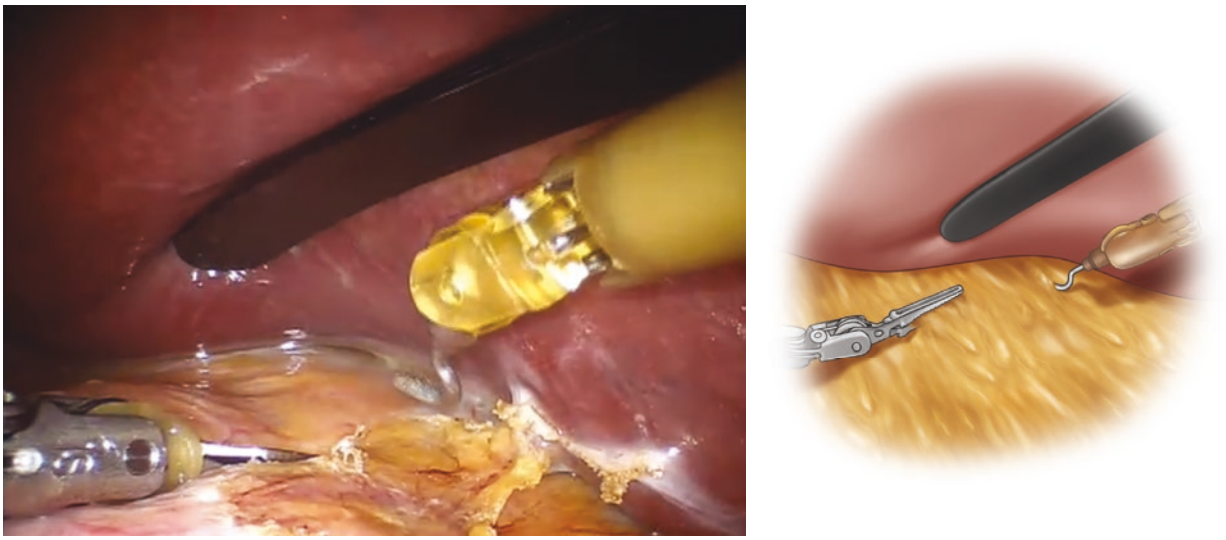

Fig. 9.1 Division of the right triangular ligament and the liver retraction

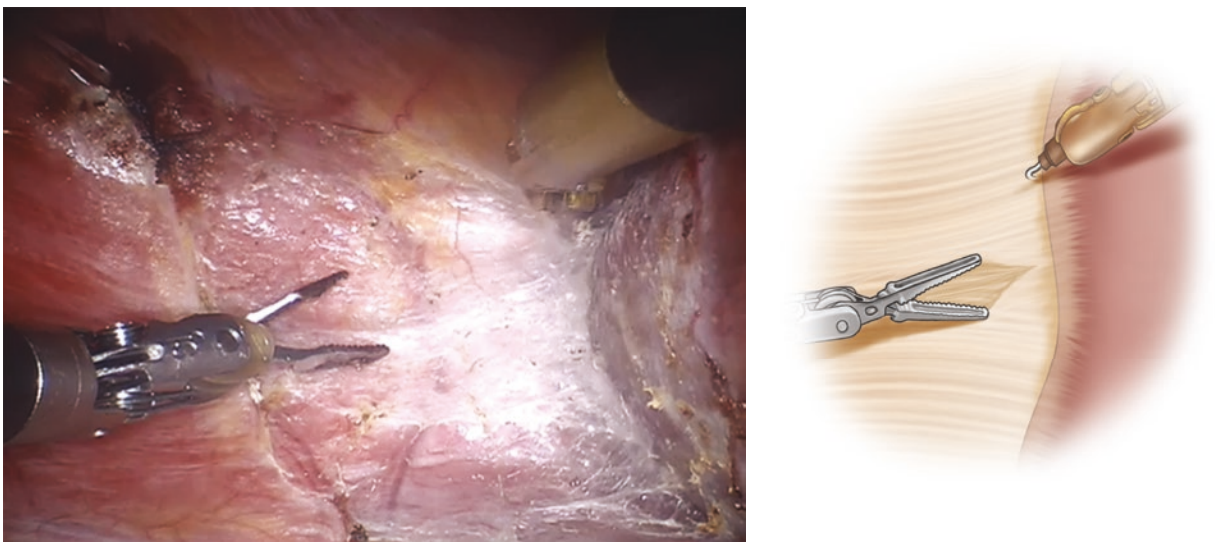

Fig. 9.2 Right triangular ligament dissection (details)

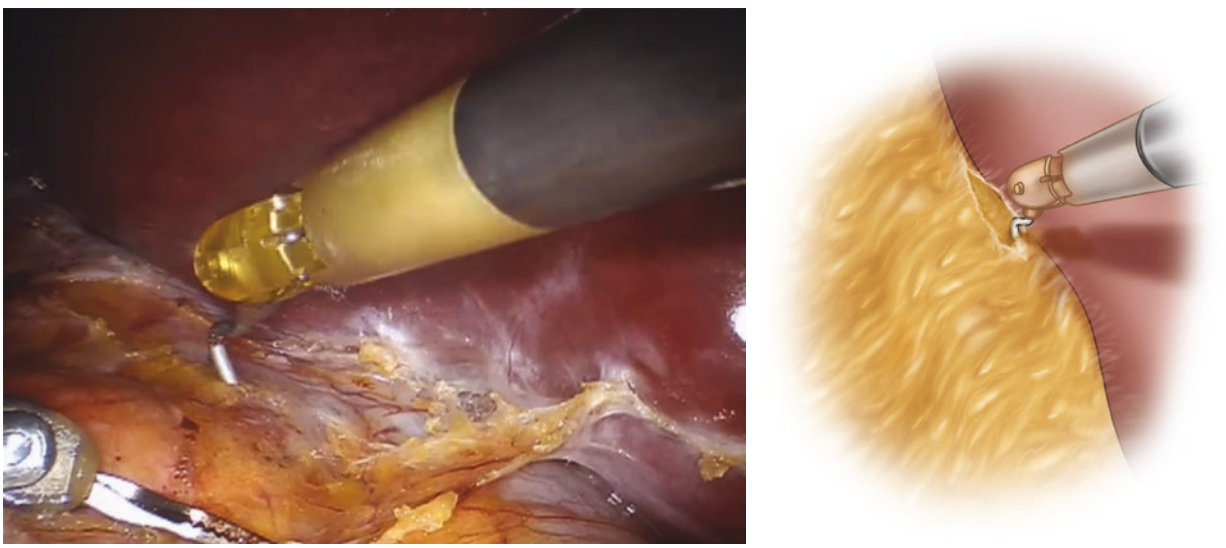

Fig. 9.3 Exposition of the retrohepatic part of the vena cava

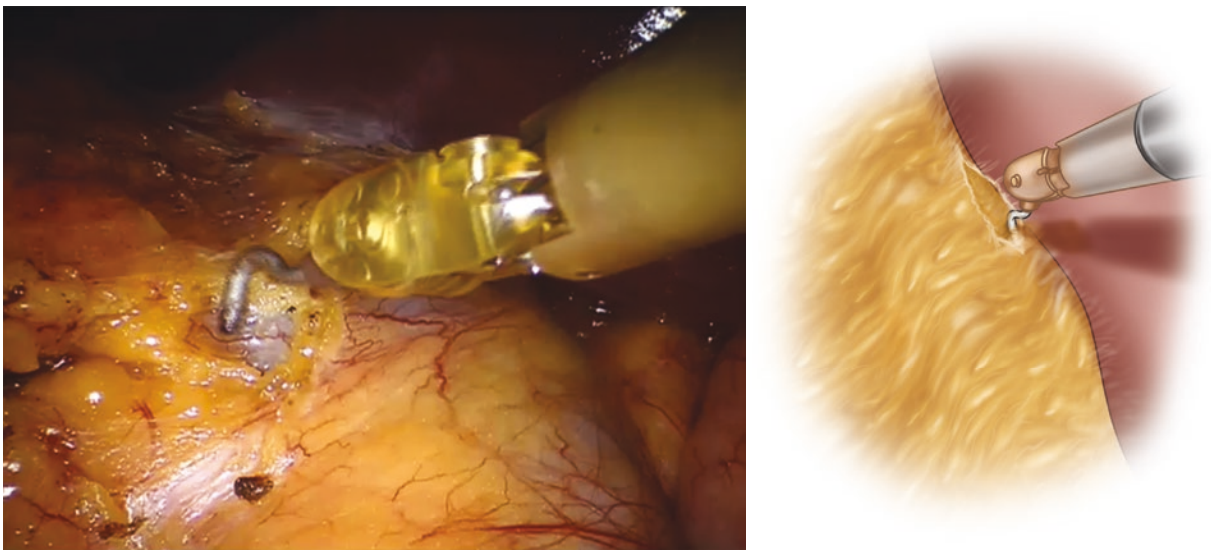

Fig. 9.4 Dissection of the right aspect of the retrohepatic vena cava

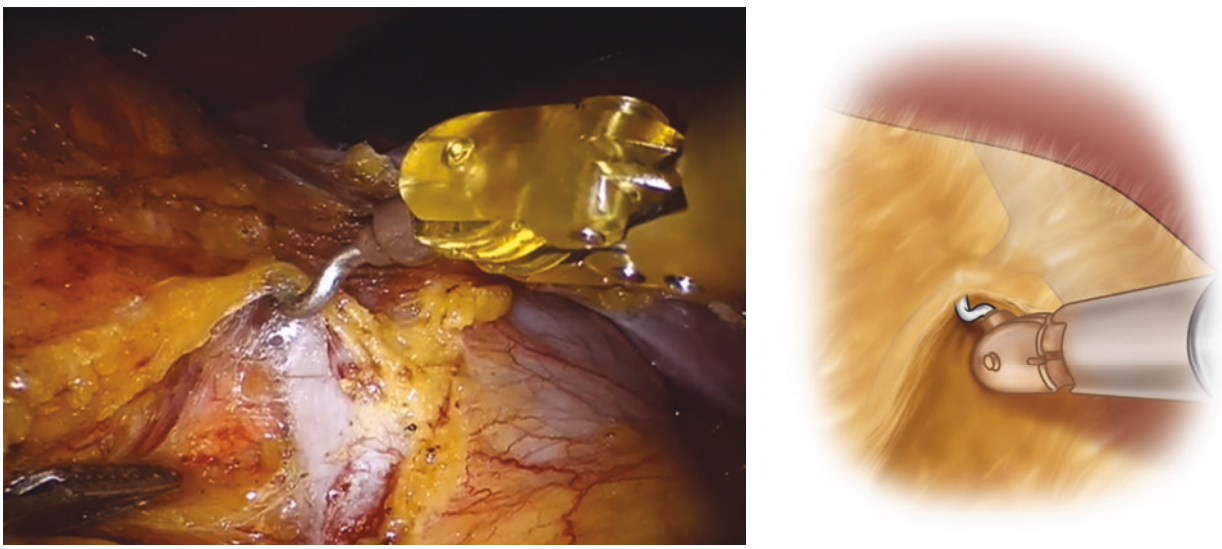

Fig. 9.5 Further dissection was carried out progressively upward along the inferior vena cava

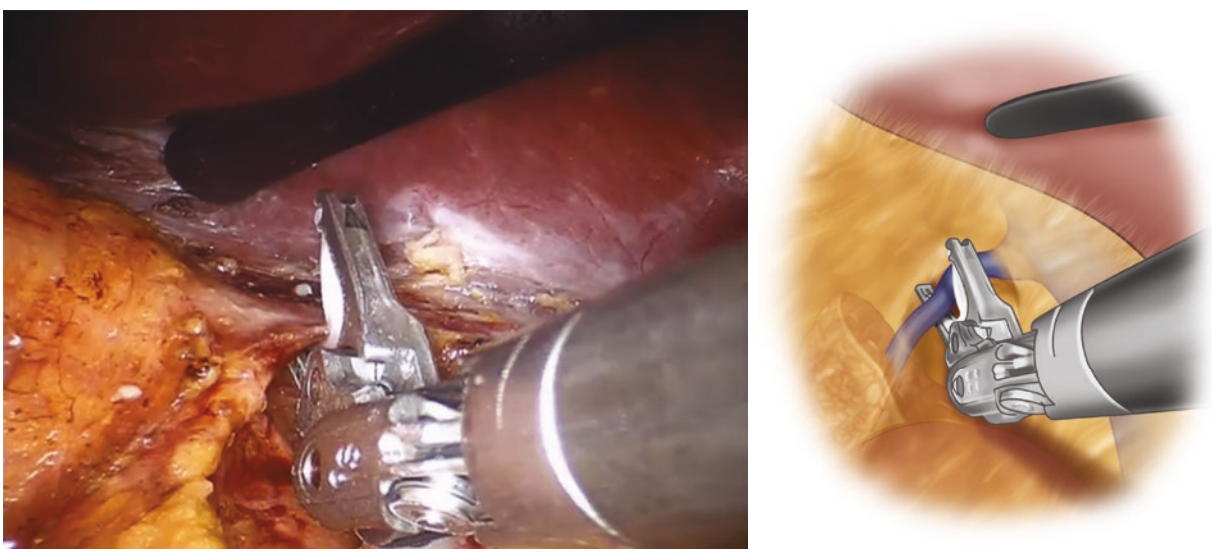

Fig. 9.6 First clip on the right main adrenal vein

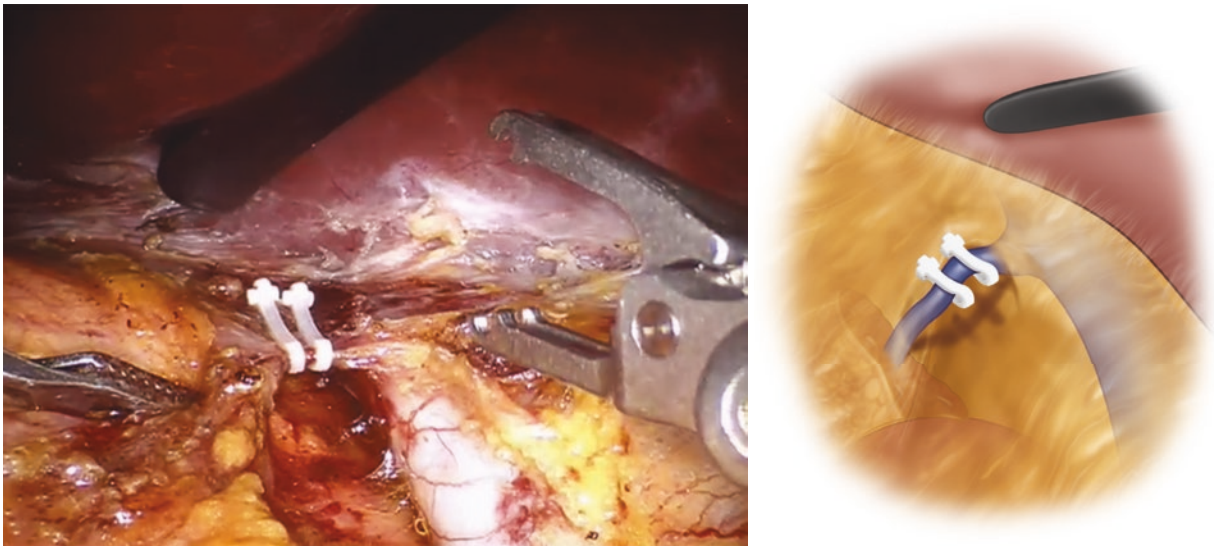

Fig. 9.7 Second clip on the right main adrenal vein

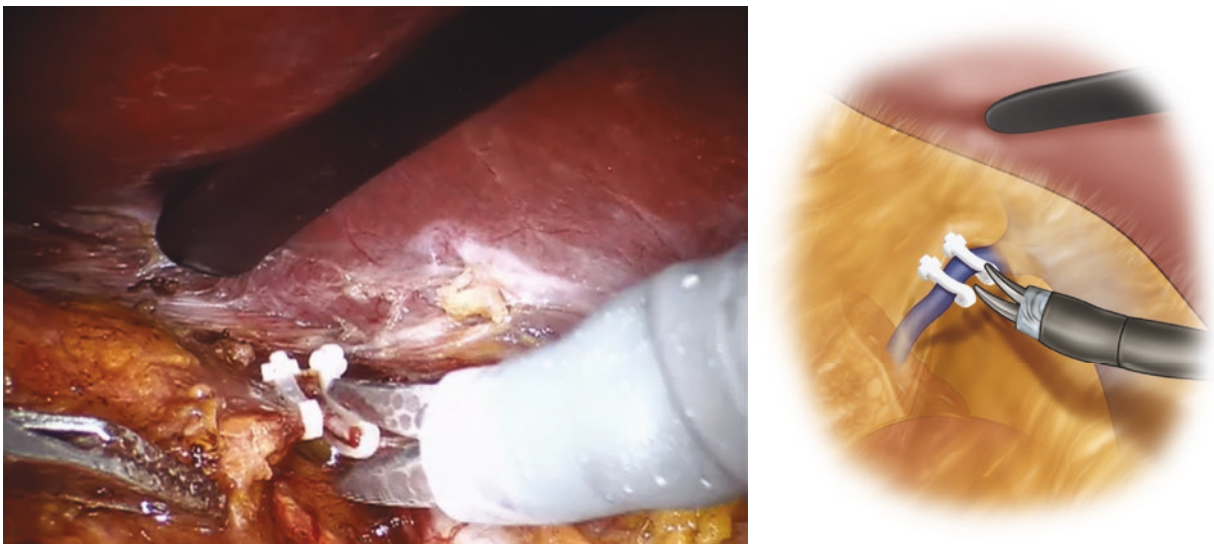

Fig. 9.8 Section of the right main adrenal vein between clips

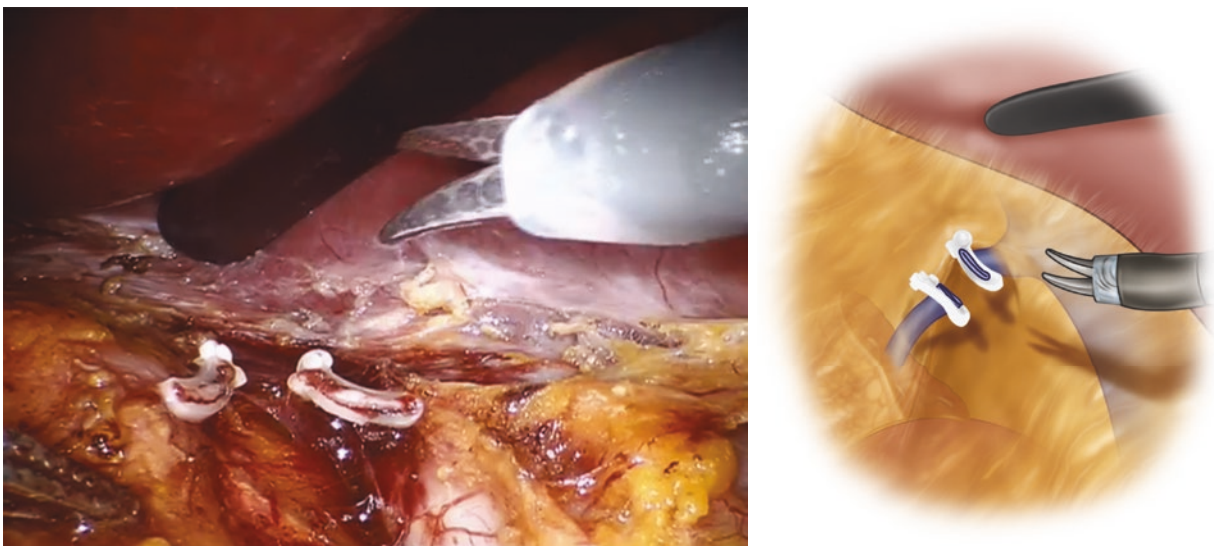

Fig. 9.9 Final view after the section of the right main adrenal vein

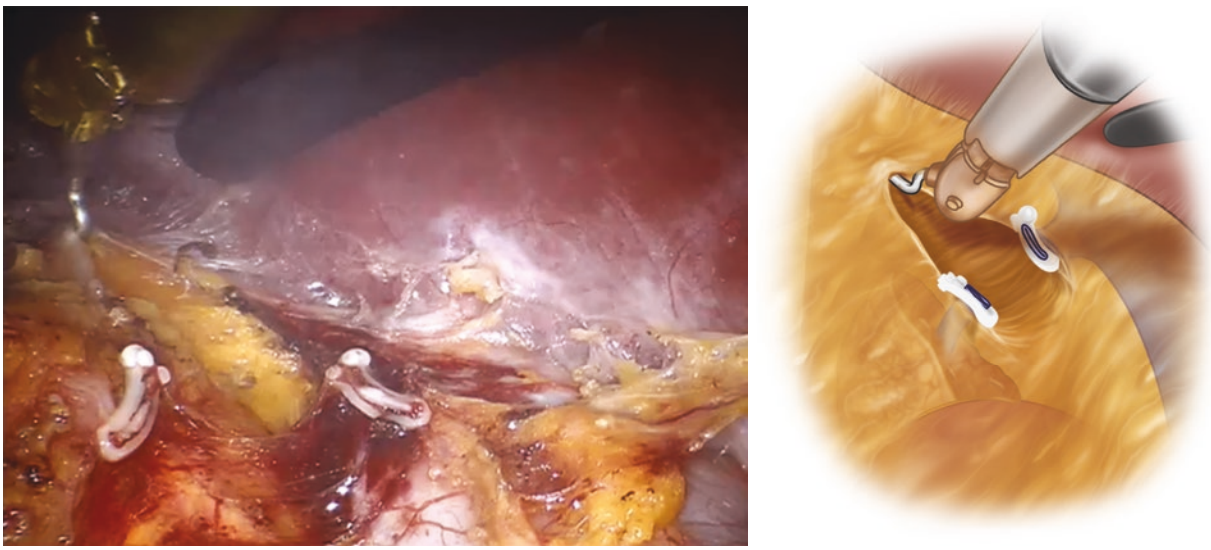

Fig. 9.10 Dissection of the upper pole of the right adrenal gland

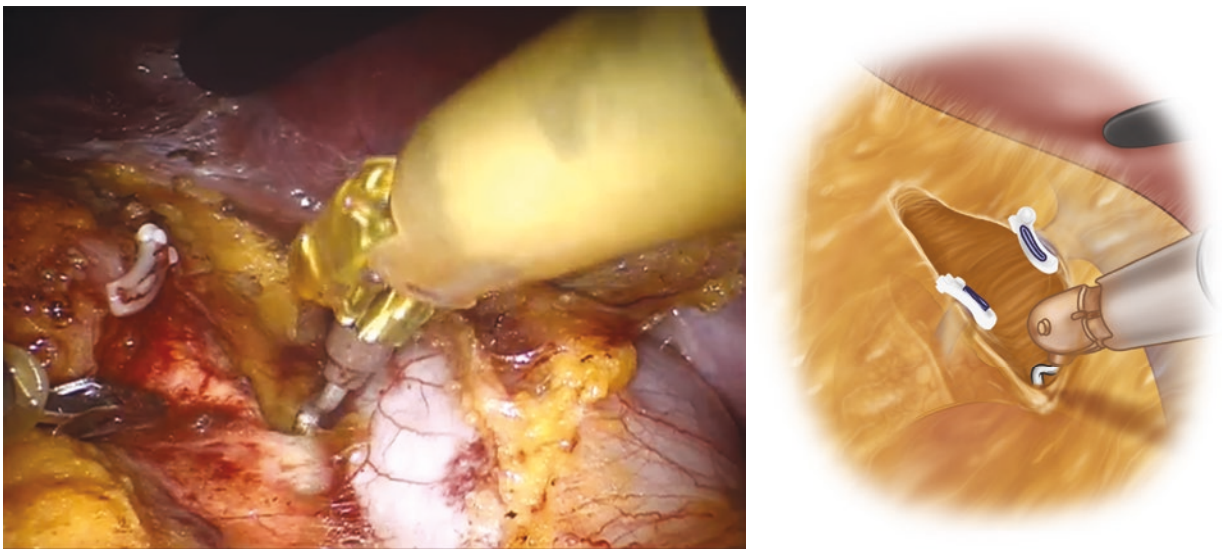

Fig. 9.11 Dissection of the lower pole of the right adrenal gland

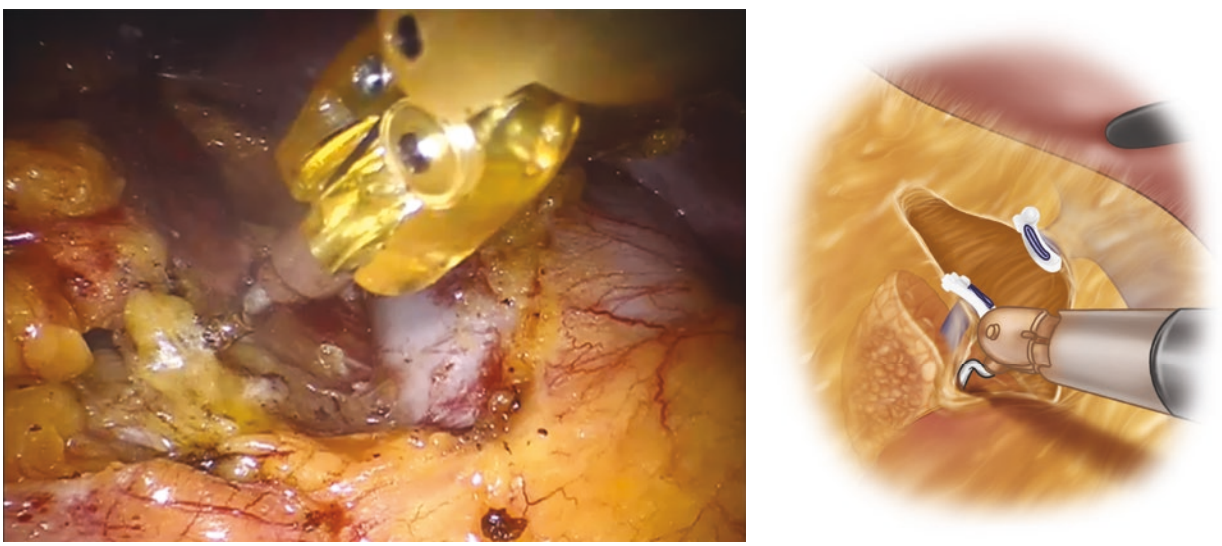

Fig. 9.12 Initial dissection of the adrenal mass and mobilization from its posterior aspect (iliopsoas muscle) (initial)

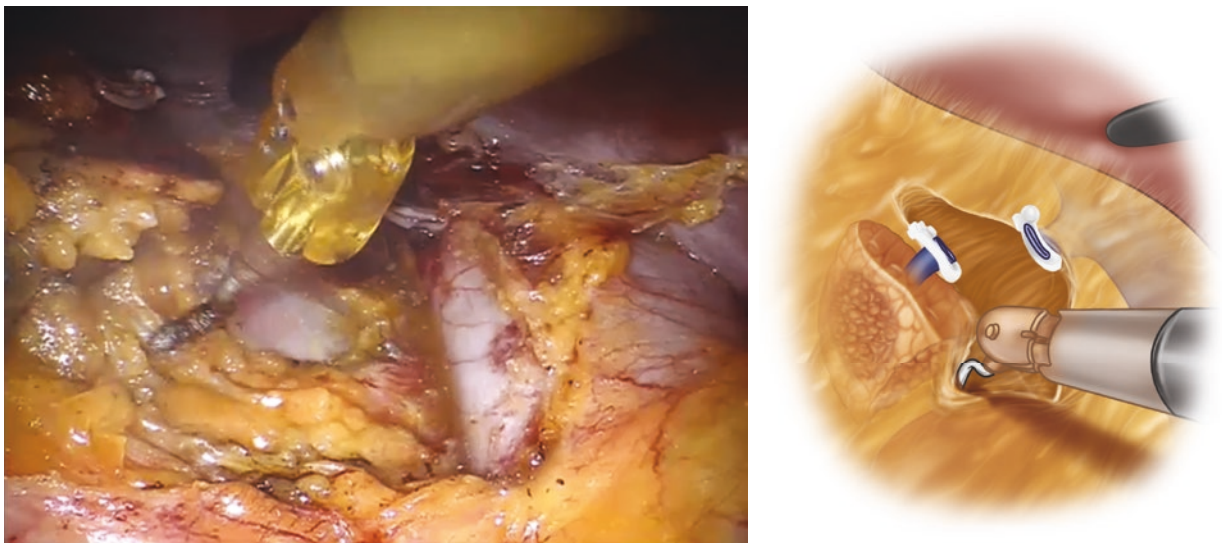

Fig. 9.13 During dissection of the adrenal mass and mobilization from its posterior aspect (iliopsoas muscle)

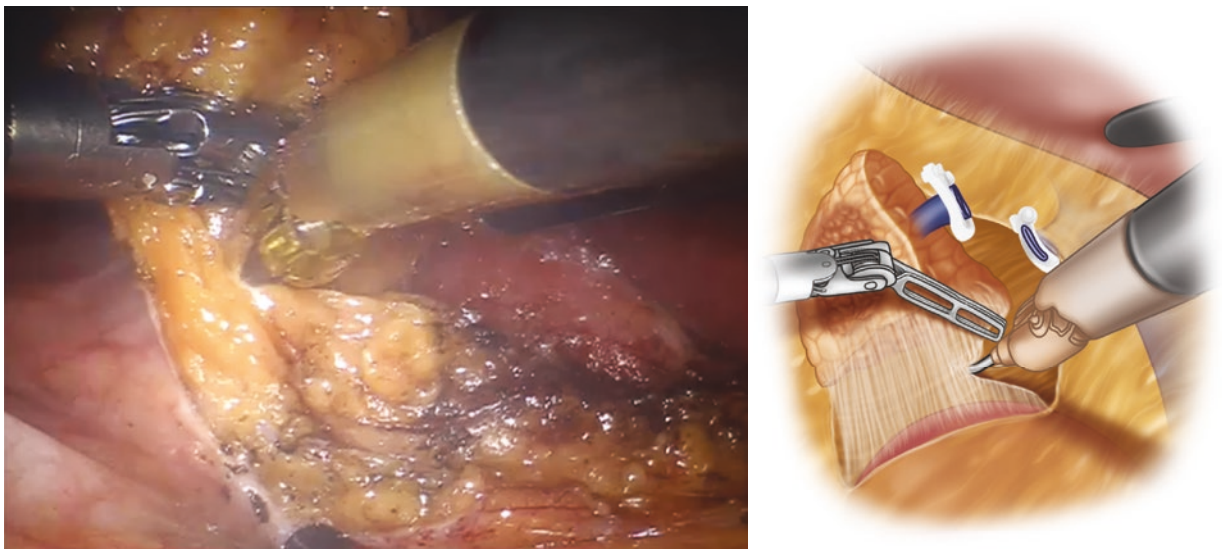

Fig. 9.14 Further dissection of the adrenal mass and mobilization from its posterior aspect (iliopsoas muscle)

Fig. 9.15 Final dissection of the adrenal mass and mobilization from its posterior aspect (iliopsoas muscle)

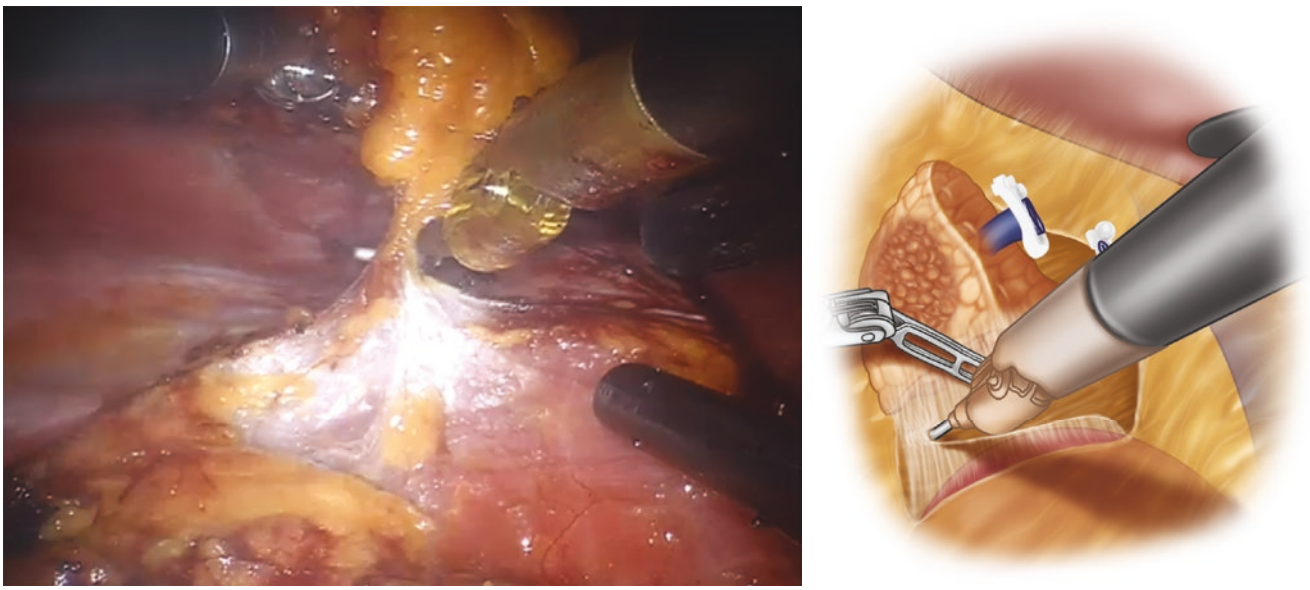

Fig. 9.16 Extraction of the right adrenal gland

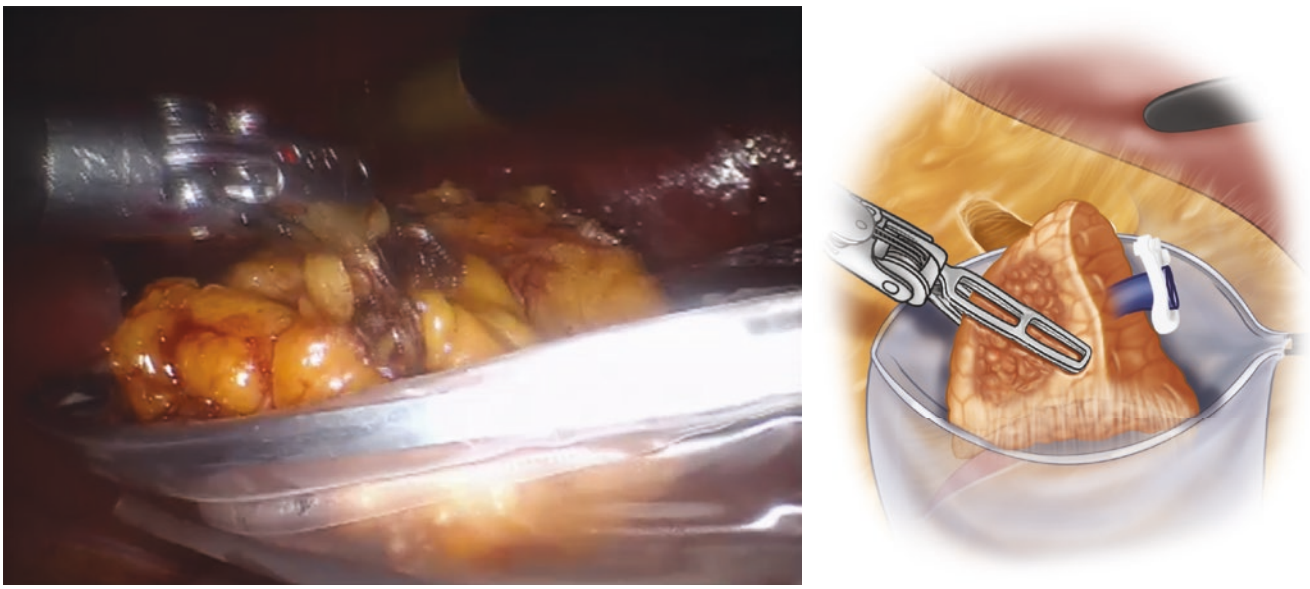

Fig. 9.17 The specimen is taken out using an Endo Catch bag

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Right Transabdominal Robotic Adrenalectomy

10

Hyunsuk Suh and William B. Inabnet III

Introduction

Since its introduction in the early 2000s, some surgeons have adapted a robotic platform and combined the benefits of minimally invasive surgery and the advanced robotic surgery such as 3D visualization, magnification, refined dissection, and instrument maneuverability.

Like laparoscopic adrenalectomy, robotic adrenalectomy can be performed via the transabdominal and retroperitoneal approaches, depending on training and preference. The literature has generally demonstrated the safety and efficacy of both approaches, but this chapter will focus on the right transabdominal robotic adrenalectomy approach [1–4].

There is wide agreement that the advantages of transabdominal approaches are optimal working space, familiar anatomic landmarks, and easy conversion to open surgery, which makes the approach more suitable for larger, potentially malignant, and otherwise challenging cases.

The learning curve for the robotic adrenalectomy will depend on the surgeon's general experience in adrenalectomy as well as robotic skills, but based on previous studies, after a learning curve of 20–30 robotic adrenal procedures, surgical outcomes were equivalent to those following laparoscopic surgery.

Overall perioperative considerations and management for robotic adrenalectomy are similar to those of laparoscopic transabdominal adrenalectomy approach (see Chap. 3).

Transabdominal Robotic Right Adrenalectomy Surgical Technique

The surgical technique is described in Figs. 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 10.9, 10.10, 10.11, 10.12, 10.13, 10.14, 10.15, 10.16, and 10.17 and Video 10.1.

Discussion and Pitfalls

General indications and contraindications as well as key surgical principles of safe and sound techniques for robotic-assisted adrenalectomies are like those of the laparoscopic approach.

Since the first laparoscopic adrenalectomy by Gagner et al. [5] in 1992, laparoscopic adrenalectomy became a standard of care for benign adrenal tumors and incidentalomas. The first robotic adrenalectomy was performed by Piazza et al. [6] in 1999, and although numerous studies have been published, no clinically meaningful advantages have been demonstrated for these two approaches [2, 4, 6–10]. Depending on the surgeon's preference and training background, both laparoscopic and robotic approaches can be performed safely and effectively.

Open adrenalectomy is the current standard of care for adrenal cortical carcinoma or large adrenal tumors with high suspicion for malignancy [11].

Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-030-01787-3_10) contains supplementary material, which is available to authorized users.

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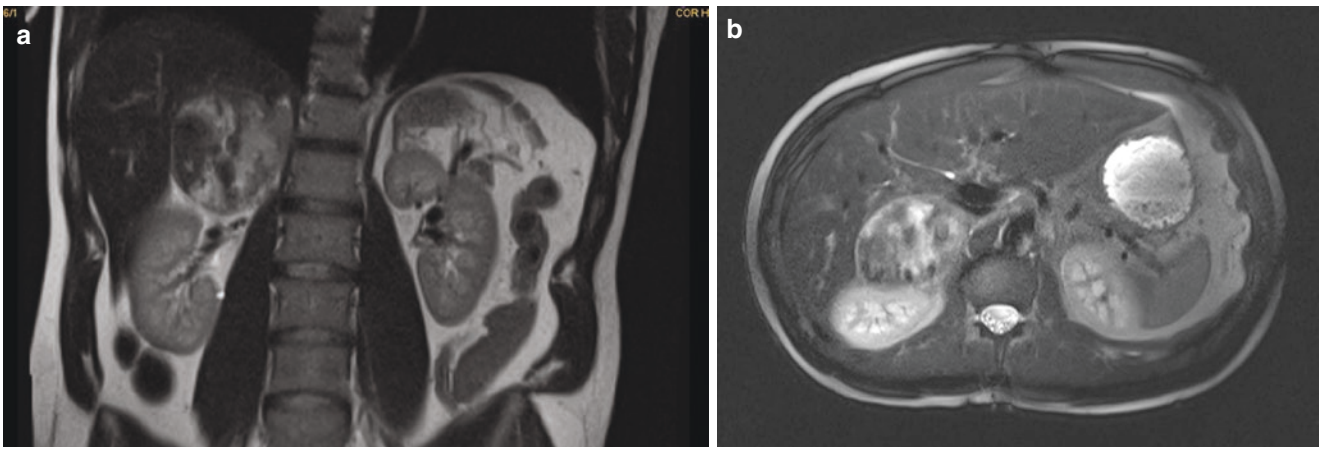


Fig. 10.1 (**a**, **b**) Indication for surgery: a 33-year-old man with type 1 cutaneous neurofibromatosis presenting with 1-year history of hypertensive episodes and 10-cm right adrenal mass on magnetic resonance imaging (MRI). Biochemical testing revealed elevated normetanephrines and metanephrines. Contralateral adrenal gland was normal, and there was no evidence of extra-adrenal lesions suggestive of paraganglioma. Neurofibromatosis confers increase in risk of paraganglioma and bilateral pheochromocytoma. Cortical-sparing right adrenalectomy was therefore considered, but given the size of the adrenal lesion, complete adrenalectomy was chosen for this patient, with close postoperative surveillance for recurrence. The patient was treated preoperatively with an alpha blocker (phenoxybenzamine titration for 14 days) followed by a beta blocker (propranolol) for a reflexive tachycardia

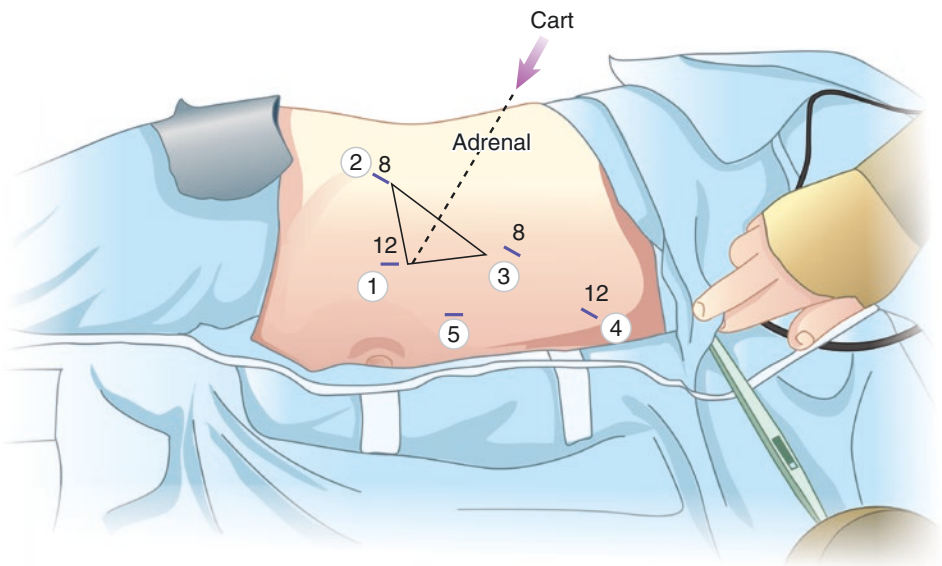


Fig. 10.2 Patient positioning. Complete lateral decubitus with flexion to maximize the space between the iliac crest and the costal arch (similar to the laparoscopic approach)

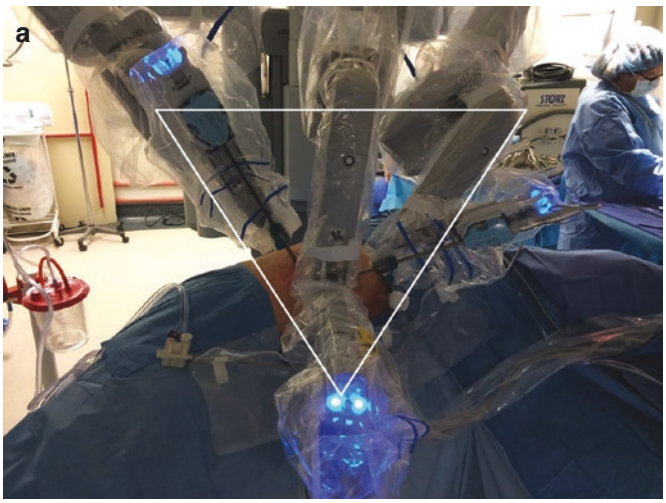
Entry: Hasson or gasless direct entry can be used for right adrenalectomy

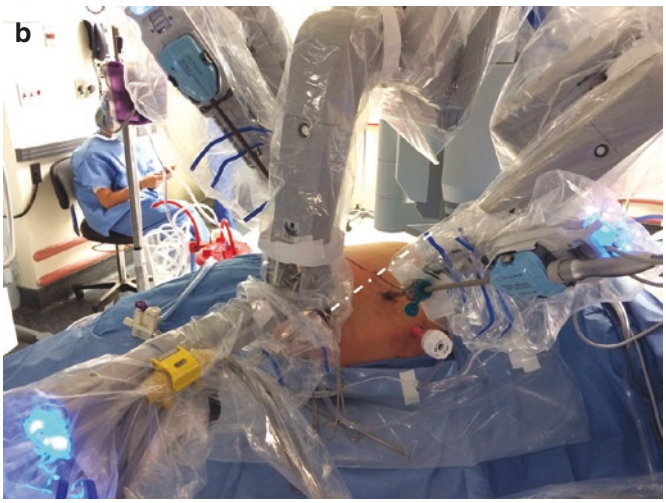
Port sites:

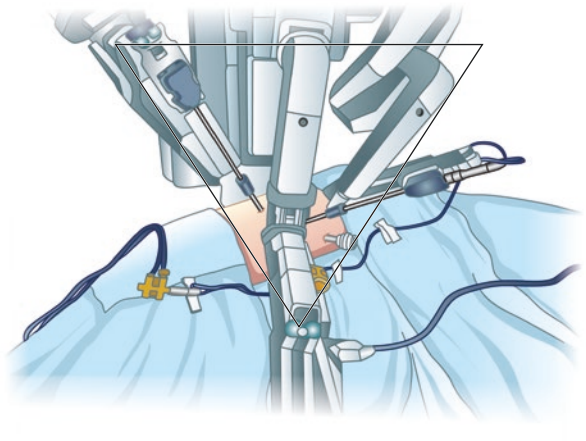
A total of 4–5 trocars, including the camera, robotic instrument, and assistant trocars, can be utilized. Depending on the preference, liver retraction can be performed with either robotic or laparoscopic instruments. In this case, liver retraction is facilitated using the Endo Paddle Retract 12-mm instrument (Medtronic; Minneapolis, MN, USA), which provides an atraumatic retraction for the liver and adrenal tumor.

In general, robotic trocars should be separated by at least 8 cm for optimal maneuverability.

1. Camera trocar should be placed at the paramedian line at the level of umbilicus. Vertical incision should be utilized for extensibility and for posterior and anterior fascial closure.
2. Lateral robotic instrument (5–8 mm): 3–4 cm superior to the right ASIS and at least 8 cm from the camera trocar.
3. Medial robotic instrument (5–8 mm): 2–3 cm below the costal margin at the midclavicular line and at least 8 cm from the camera trocar.
4. Assistant trocar (12 mm) epigastric for liver retraction. Alternatively, a third robotic arm can be used instead.
5. Optional second assistant trocar (5 mm) for suction irrigation or additional retraction if needed.







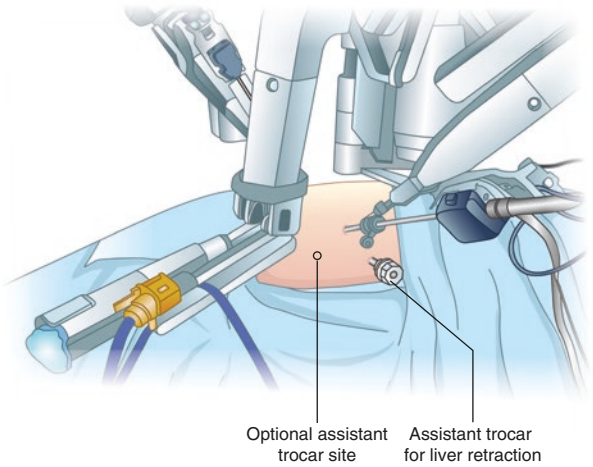


Fig. 10.3 (**a**, **b**) Cart positioning and docking: Cart should be approached so that the post of the cart, adrenal gland, and camera trocar is aligned on the same axis. Furthermore, good triangulation of the trocars and adequate trocar distance minimize the robotic arm fighting. Adjust the robotic arms to maintain the ideal triangulation

Instrument selection (5- or 8-mm instruments for retraction, dissection, and energy device).
Robotic instruments:
Hemostatic and energy devices (i.e., ultrasonic dissector, vessel sealer, bipolar, monopolar, clip applier, etc.)

Grasper and dissector forceps (i.e., double fenestrated, Maryland, PK, etc.). Double fenestrated grasper is an atraumatic grasper with the longest jaw length (3.3 cm), which is ideal for retraction and tissue maneuver.
Assistant trocar:
Liver retractor 5–12 mm (i.e., 12-mm Endo Paddle retractor, etc.)

Laparoscopic instruments (grasper, suction irrigation device, clip applier, etc.)

Perioperative management: Multidisciplinary approach for an accurate diagnosis and medical management should be performed perioperatively.

Trocar positioning:

- Good triangulation of the trocars and adequate trocar distance minimizes the robotic arm fighting. For obese patients, consider using extra-long trocars and adjust the angle during the trocar insertion to minimize tension on the abdominal wall.

Tumor/adrenal gland exposure:

Tissue dissection:

- In general, perform an anatomic dissection along the avascular plane and perirenal and periadrenal fat tissue to avoid adrenal capsular injury and bleeding.
- Adequate mobilization of the liver for the superior margin of the tumor and dissection along the readily identifiable superior pole of the kidney often provides a clean dissection plane.

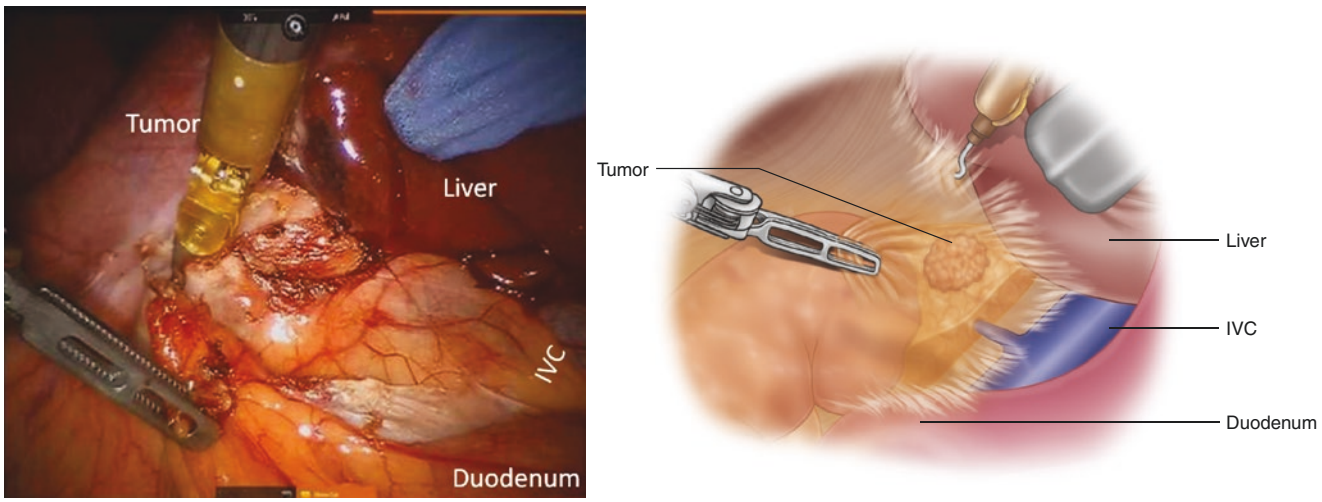


Fig. 10.4 Mobilization of the liver and exposure. Dense adhesions between the adrenal tumor and the liver are carefully dissected and separated without capsular injuries to the tumor or the liver. Important landmarks should be identified (i.e., IVC, duodenum, gallbladder, stomach, kidney, etc.)

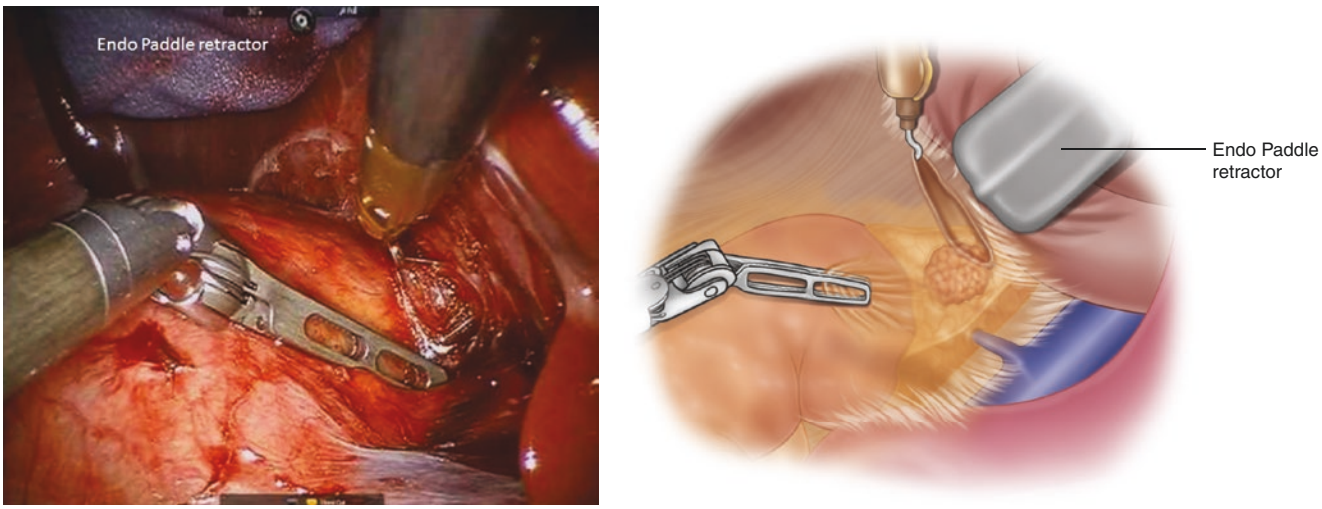


Fig. 10.5 Superior margin of the tumor should be completely dissected down toward the psoas muscle and diaphragm. Retraction is provided by the Endo Paddle retractor

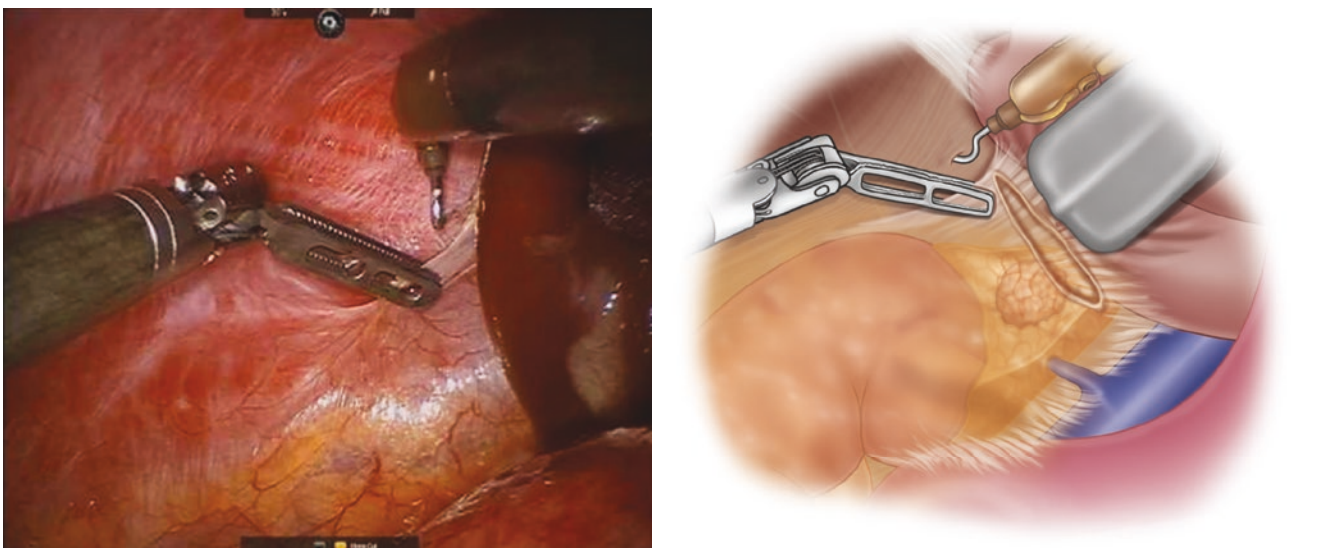


Fig. 10.6 The right triangular ligament of the liver is divided for further exposure

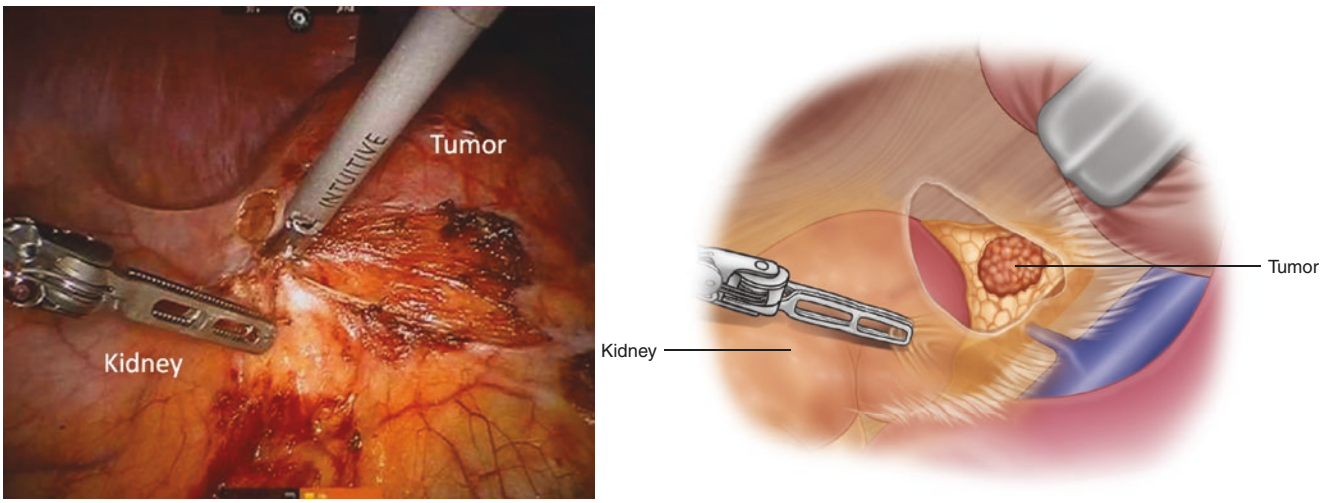


Fig. 10.7 Gerota's fascia dissection and inferior margin exposure. Plane between the kidney and tumor is developed by dividing Gerota's fascia

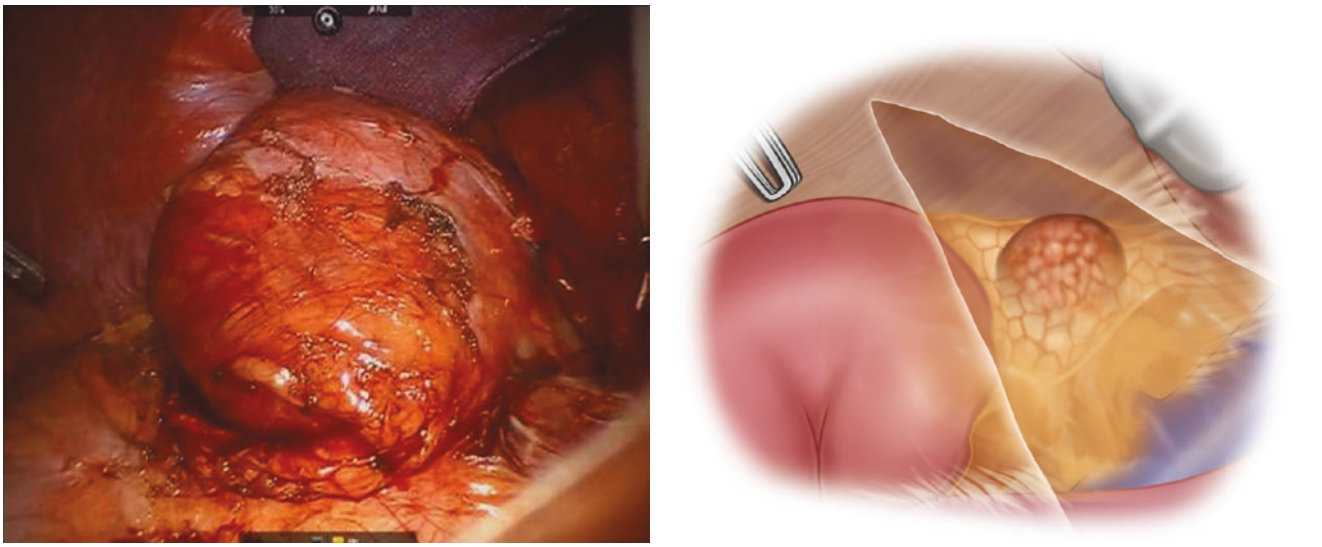


Fig. 10.8 The tumor should be well mobilized and devascularized at the end of dissection, except the medial margin

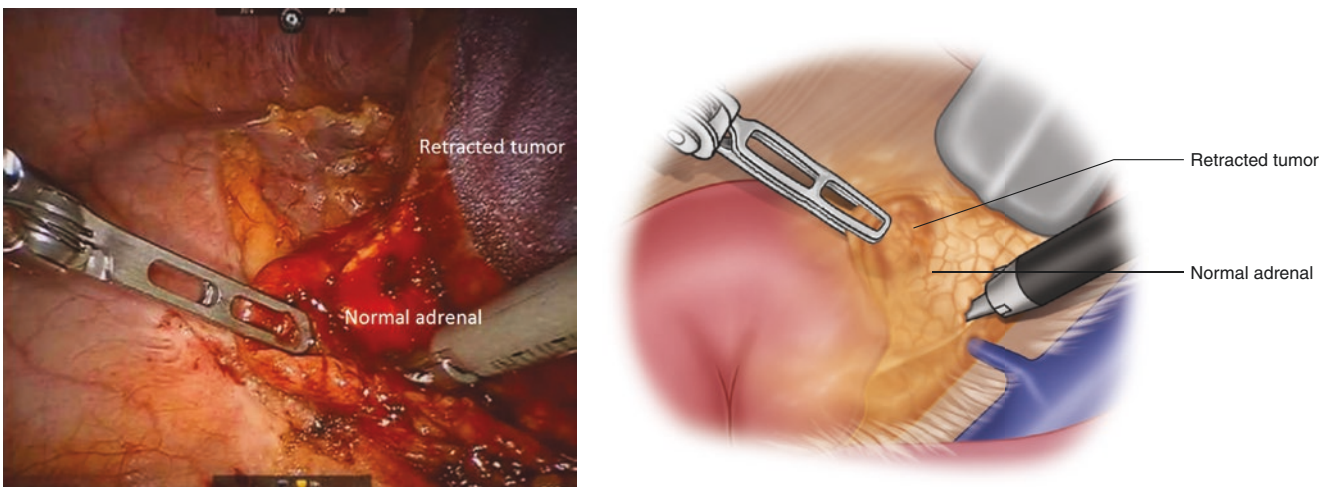


Fig. 10.9 Normal adrenal tissue was identified along the posterior margin. Instead of performing a cortical-sparing adrenalectomy, given the size of the tumor, clean resection of the adrenal tumor was performed

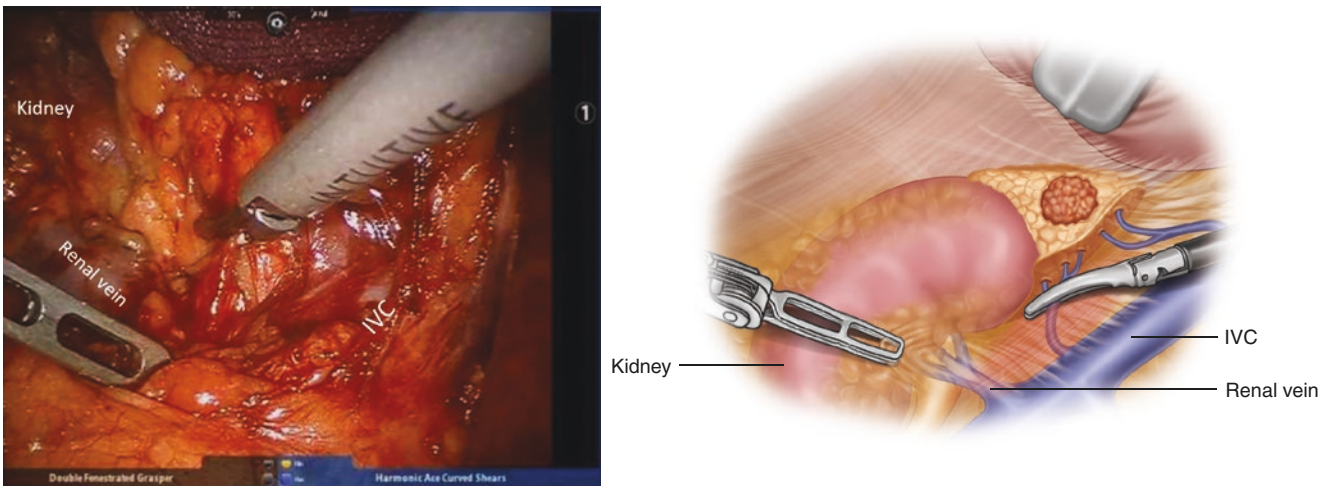


Fig. 10.10 Renal vein and IVC are identified and carefully dissected via retracting the large tumor cephalad and laterally. Perirenal fat is dissected to avoid capsular or subcapsular dissection of the gland

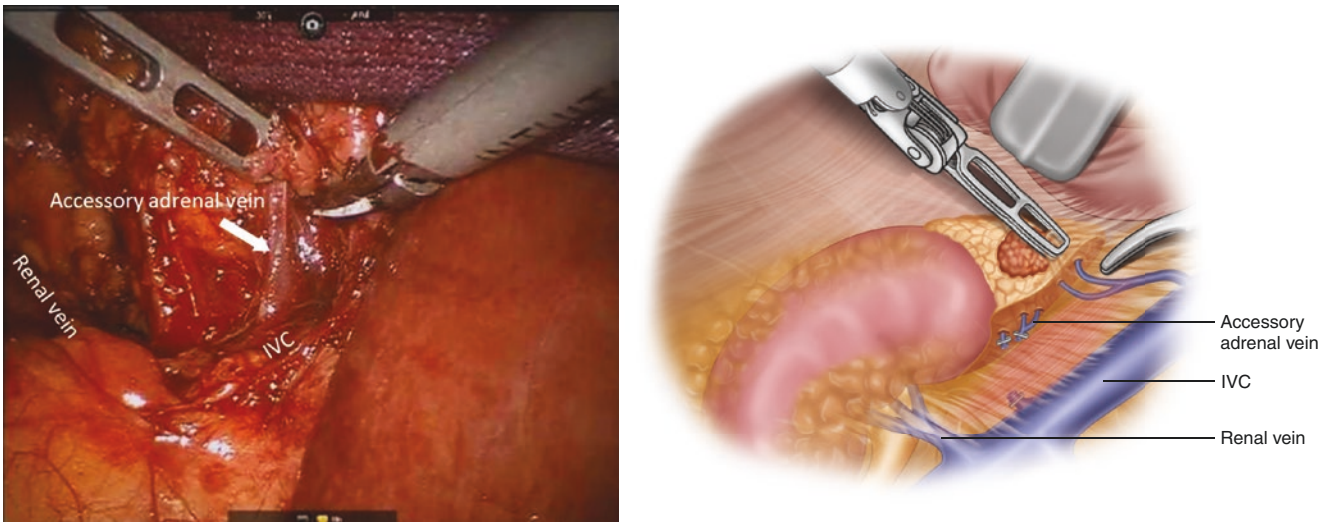


Fig. 10.11 Multiple adrenal veins may be present especially when the tumor is large and vascular such as in pheochromocytoma. Ligation of accessory adrenal vein at the inferior aspect of the IVC near the renal vein

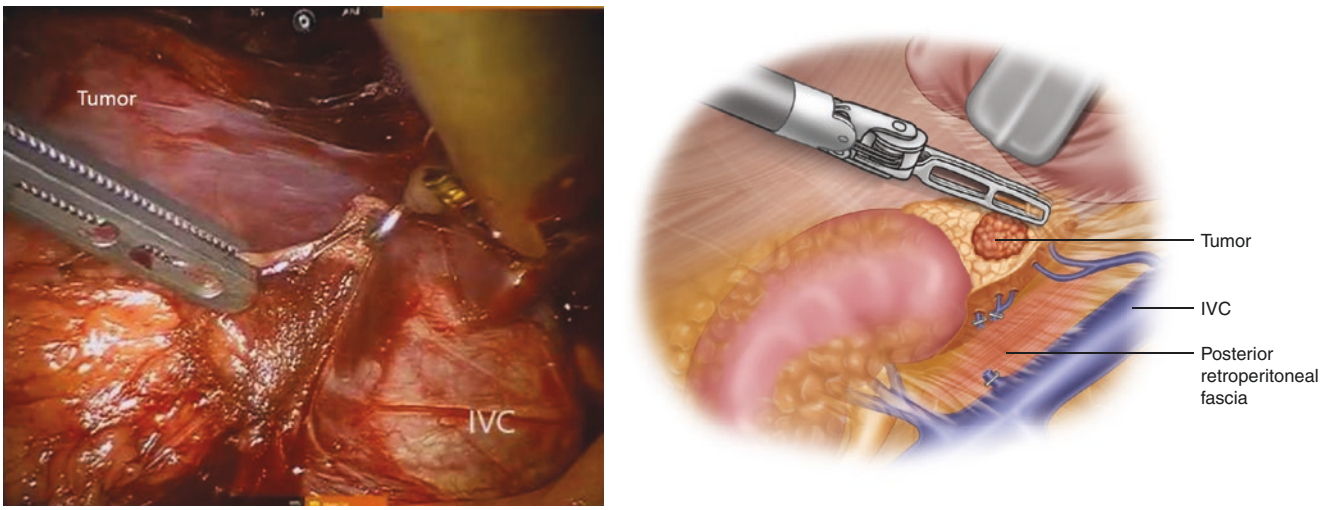


Fig. 10.12 Medial border is dissected by dividing the peritoneum between the IVC and the tumor

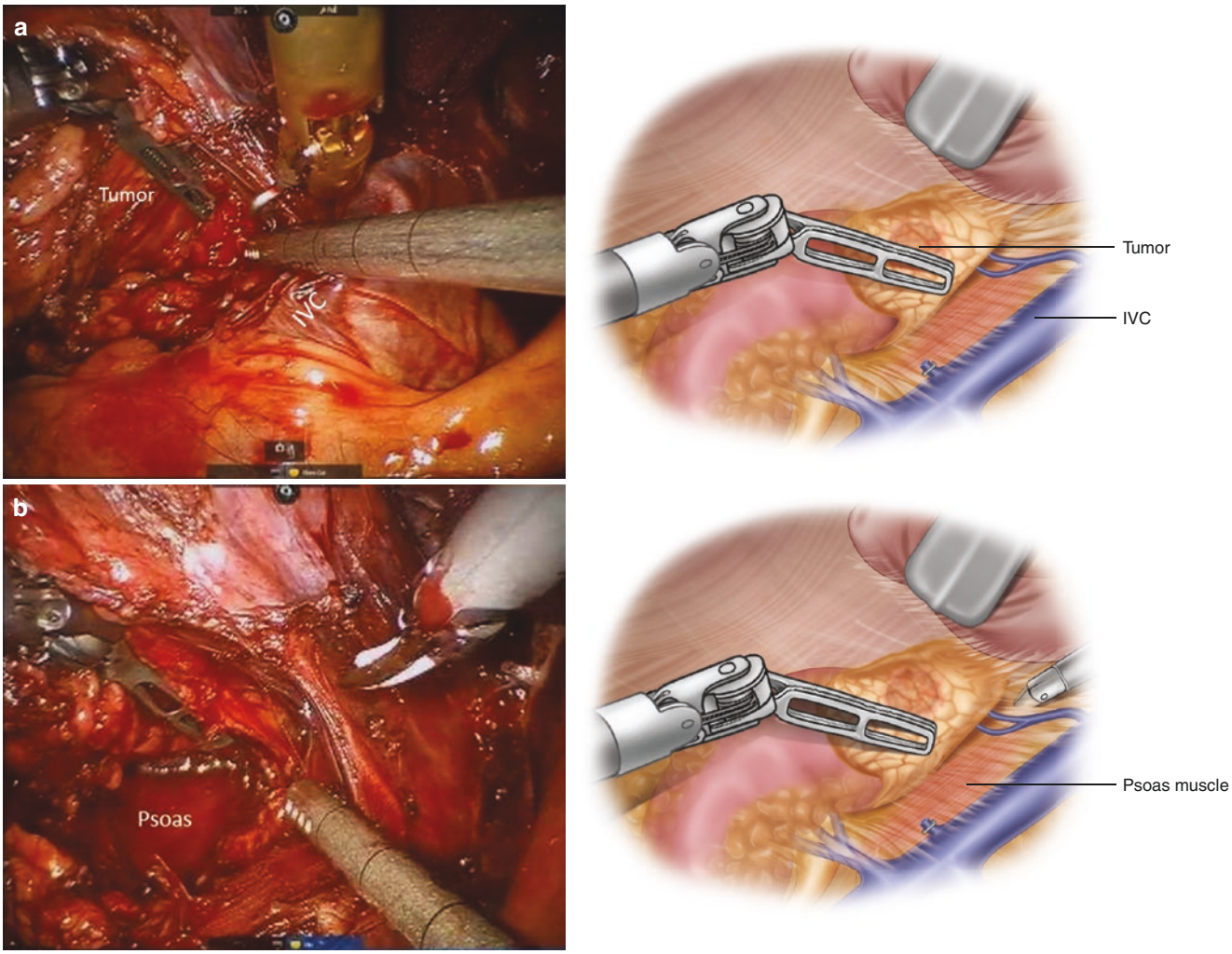


Fig. 10.13 (**a**, **b**) Traction and countertraction are applied by the robotic instrument and suction irrigation device for the tumor and IVC, respectively, for an optimal visualization and safe dissection. Retroperitoneal fascia is exposed as a posterior margin. The tumor is retracted laterally and anteriorly away from the IVC

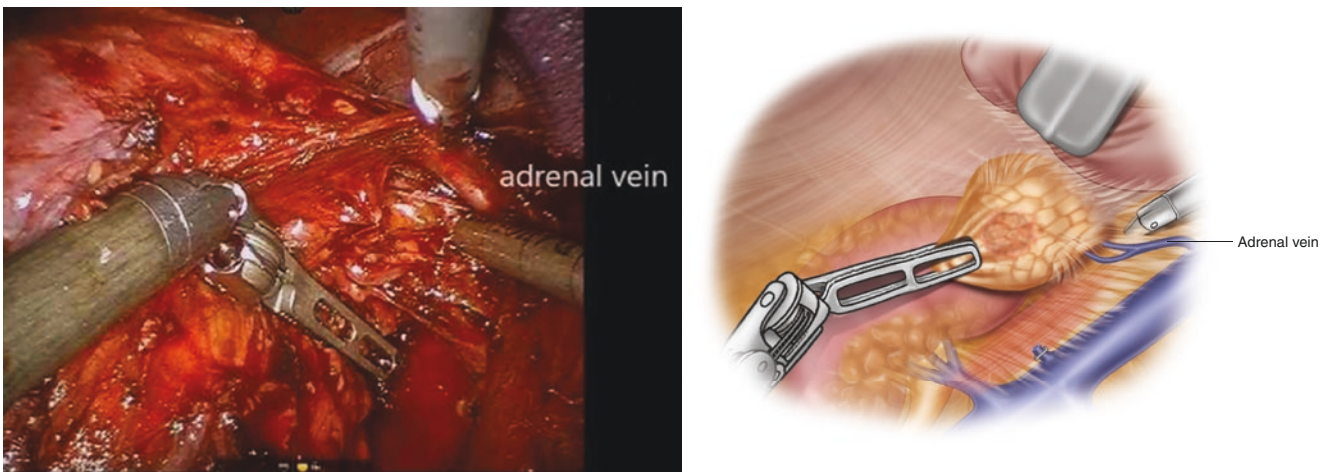


Fig. 10.14 At the superior margin, the adrenal vein is localized and ligated using an ultrasonic energy device

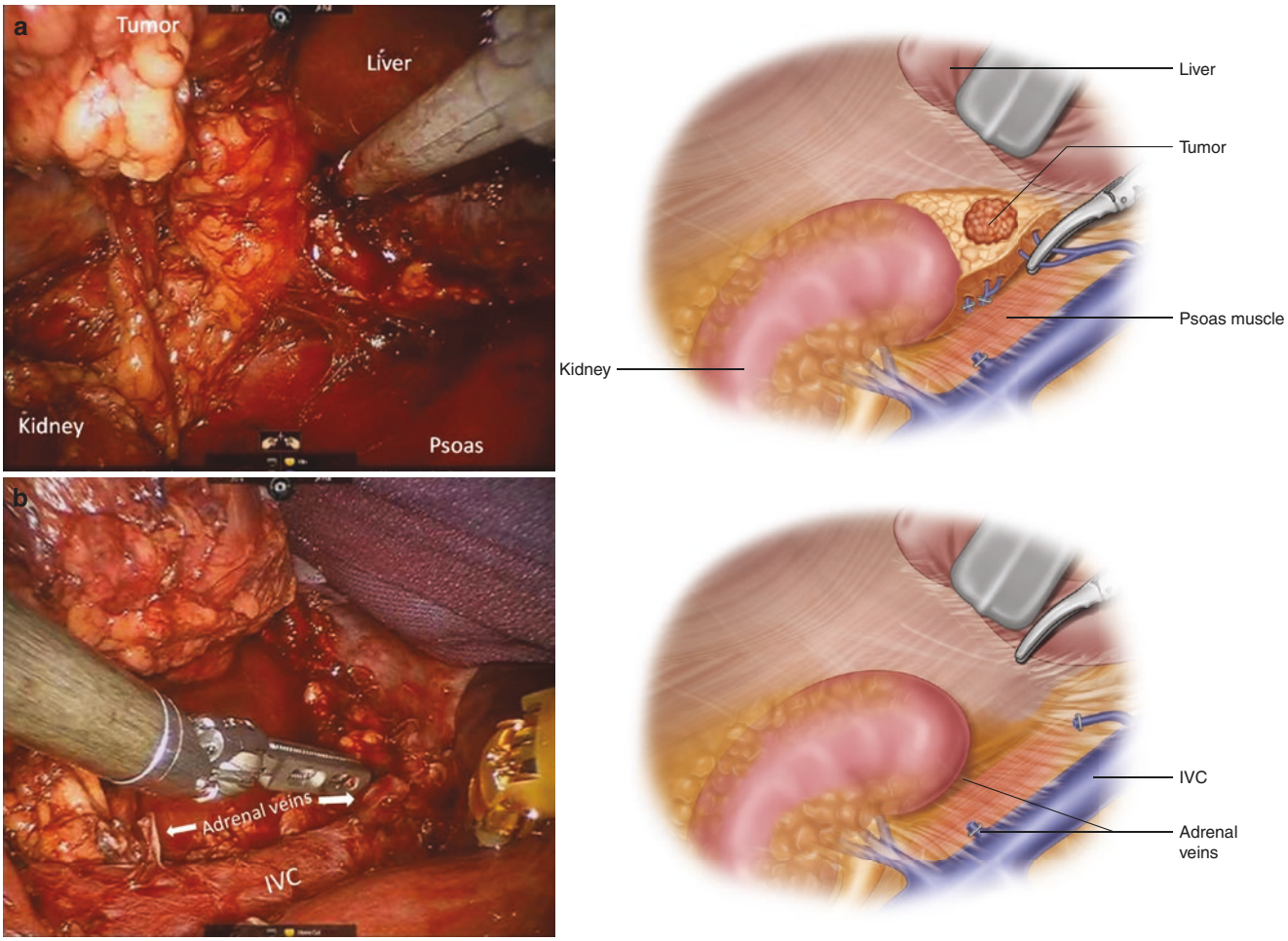


Fig. 10.15 (**a**, **b**) Posterior attachments and periadrenal fat tissues are completely dissected off the retroperitoneum. Tumor bed is checked for good hemostasis including the ligated adrenal vein(s)

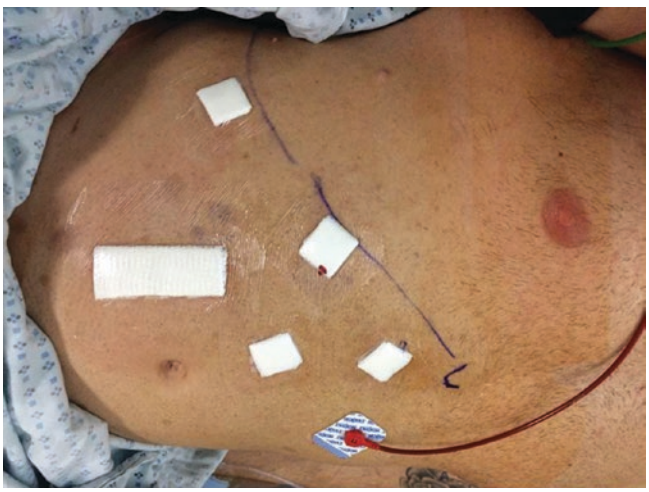


Fig. 10.16 The paramedian camera trocar site incision was extended vertically for a specimen retrieval in an endoscopic specimen bag

Fig. 10.17 Final pathology showed pheochromocytoma (11.0 × 8.2 × 5.3 cm 208.4 g; intact capsule and no evidence of malignancy)

- Hepatic flexure of the right colon mobilization is usually not necessary.
- Posterior dissection is performed along the psoas and quadratus lumborum muscle toward the lateral diaphragmatic attachments.

Adrenal vein localization and ligation:

- Adrenal vein localization and ligation can be done safely during either early in the exposure or once the gland and the tumor have been well mobilized and devascularized.
- The adrenal vein can be ligated and divided either with advanced energy devices such as ultrasonic devices or with clip and endoscopic scissors.
- The right adrenal vein is usually short and located near the anterior margin of the adrenal gland to the posterolateral aspect of the inferior vena cava (IVC) near the apex.
- Accessory adrenal vein may be present.

Specimen extraction and closure:

- Once the specimen is ready for extraction, robotic arms are undocked, and the specimen is extracted via the paramedian incision (camera trocar) in an endoscopic bag.
- Paramedian incision is extended vertically as needed.
- Routine drain placement is not indicated.
- Abdominal wall fascia is closed in two layers (anterior and posterior rectus sheath).

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